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Teaching Medical Students Cardiac Rhythm Recognition (RR) and AHA Algorithm-Based Management (AAM) of Cardiac Emergencies Using Coloured Scaffolds

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ABSTRACT

Cardiac emergencies require rapid, accurate rhythm recognition and algorithm-based decision-making, yet these remain among the most cognitively demanding skills for medical students to obtain. Conventional teaching, taught mainly through static flow charts and didactic lectures, places a high extraneous cognitive load on novice learners and offers little scaffolding for the transition from recognising a rhythm to carrying out a coordinated team response. This study explores the use of coloured scaffolds, colour-coded, step-by-step learning templates based on Cognitive Load Theory, Dual Coding Theory, Scaffolding Theory, and the Zone of Proximal Development, to teach undergraduate medical students Cardiac Rhythm Recognition (RR) and AHA Algorithm-Based Management (AAM) of cardiac emergencies. This is a quantitative pilot study using a 5-point Likert-scale survey administered to a convenience sample of 30 undergraduate medical students. The 27-item instrument, organised into four constructs (Skills Needed, Teaching Using Colours, Teaching Step-by-Step, and Teaching Using Templates), showed good overall reliability (Cronbach's alpha = .807). The study indicates that students perceived the greatest difficulty in team-based leadership and communication, algorithm application under time pressure, and skill decay between practice sessions, while the technical/psychomotor components of resuscitation that students rated as relative strengths. This study supports the integration of coloured, template-based scaffolds into undergraduate resuscitation curricula, and suggests next steps for a controlled follow-up study.

Keywords: Cardiac rhythm recognition; AHA algorithm-based management; coloured scaffolds; cognitive load theory; medical education

INTRODUCTION

Background of Study

Cardiac emergencies are time-critical events in which the accurate recognition of the underlying rhythm and the correct sequential application of the American Heart Association (AHA) algorithm directly influence patient outcomes (1,2). For undergraduate medical students, Cardiac Rhythm Recognition (RR) and AHA Algorithm-Based Management (AAM) are among the most demanding competencies in the emergency medicine curriculum, requiring the simultaneous integration of pattern recognition, stepwise algorithmic reasoning, and coordinated team communication under acute time pressure. First, it's important to understand that RR and AAM educators rarely teach or assess as a single, connected skill - students who can correctly name a rhythm on a static strip frequently struggle to apply that same recognition within a live, moving resuscitation scenario, and it is this transfer gap that this study seeks to address. "Coloured scaffolds", in this paper, refers to colour-coded instructional templates that divide the AHA algorithm and its associated rhythms into clear, ordered steps, which helps learners connect colour with decision points, drug and timing cues, and role assignments (3,4). This differs from a conventional black-and-white flow chart because it intentionally combines a visual (colour) code with the verbal and textual algorithm, and reduces the unscaffolded decision-making the learner needs to make at each step. Despite the extensive ACLS and resuscitation simulation research published over the past decade the specific pedagogical value of colour- and template-based scaffolding, applied jointly to rhythm recognition and algorithm execution, is still largely unexplored - which is what makes the topic worth revisiting despite this current simulation research(5,6).

Research Gap

Resuscitation-education research suggests that most published interventions target either rhythm recognition or algorithm adherence in isolation, or evaluate colour and visual scaffolding in fields outside emergency cardiac care (7). Diaz et al. (2020) suggest more research is needed to examine how structured, low-technology training tools can be integrated into simulation to maintain communication and algorithm performance long-term, while Bowers et al. (2020) state that the self-reported confidence gains generated by simulation alone typically plateau without a structured cognitive scaffold to strengthen them between sessions (5,6). These calls for a structured, sustainable, non-simulation scaffold directly motivate this study, which studies what learners think of a coloured, step-by-step, template-based scaffold used together across the Skills, Colour, Step-by-Step, and Template aspects of RR and AAM teaching.

Objective of the Study and Research Questions

This study is done to explore the use of coloured scaffolds to teach AHA Algorithm-Based Management of Cardiac Emergencies. Specifically, this study is done to answer the following questions:

How do learners perceive their skills in their learning?

- How do learners perceive learning through colours?
- How do learners perceive learning step-by-step?
- How do learners perceive learning through templates?

LITERATURE REVIEW

Theoretical Framework of the Study

Cognitive Load Theory (Sweller, 1988), states that working memory has a strictly limited capacity, and that instructional design must manage the intrinsic, extraneous, and germane load placed on a learner if durable schema construction is to occur (1,8). Applied to this study's three target skills, the Rhythm Recognition Skill carries a high intrinsic load because students must discriminate between visually similar rhythms (for example, ventricular tachycardia versus supraventricular tachycardia with aberrancy) from long-term memory under time pressure; the Algorithm Application Skill adds further load because the learner must hold the current algorithm branch in working memory while simultaneously monitoring the rhythm and the patient; and the Team-Based Performance Skill compounds both of these with the extraneous load of real-time communication and role coordination (2).

Dual Coding Theory (Paivio, 1991) proposes that information encoded through both a verbal and a nonverbal channel is retained and retrieved more effectively than information encoded through either channel alone, because the two systems create independent, interconnected memory traces. In this study, the deliberate use of colour to code each stage of the AHA algorithm — for example, assigning a consistent colour to each drug, timing cue, or shockable/non-shockable branch, is intended to give learners a second, visual retrieval route to the same content they encounter verbally in lectures and written algorithms, providing the justification for colour as more than a decorative design choice (3).

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Scaffolding Theory (Wood, Bruner, & Ross, 1976) describes the temporary, calibrated support that allows a novice to complete a task that would be beyond their unassisted capability, with responsibility gradually transferred to the learner as competence increases. Teaching RR and AAM step-by-step operationalises this by breaking the full resuscitation algorithm into smaller, sequenced decision points, each supported by a colour cue, so that a novice is not required to hold the entire algorithm in mind before practising any single step correctly support that is intended to fade as the coloured cues are gradually withdrawn with growing proficiency (4).

Vygotsky (1978) Zone of Proximal Development describes the gap between what a learner can accomplish independently and what they can accomplish with structured support from a more knowledgeable other or a well-designed instructional tool. Teaching using templates is anchored in this theory because the coloured, step-by-step template functions as that structured support: it allows a student who cannot yet independently execute the full AHA algorithm to practise correctly within their ZPD, with the template's scaffolding intended to be withdrawn as the student's independent competence grows (9).

Past Studies

Many studies have investigated whether structured or simulation-based training improves undergraduate performance and confidence in resuscitation algorithms. The study by Bowers et al. (2020) was conducted to investigate whether high-fidelity ACLS simulation improved medical students' self-reported knowledge and confidence. Eighty-nine third- and fourth-year medical students completed simulation cases covering unstable bradycardia, supraventricular tachycardia, and ventricular tachycardia; a pre-/post-survey instrument was used, and findings showed a statistically significant increase in both knowledge (3.17 to 4.11, $p < .001$) and comfort (2.54 to 3.74, $p < .001$), with implications that simulation is a viable tool for reinforcing ACLS algorithm application even at the undergraduate level (5).

Next, the study by Kassabry et al. (2023) also looked at simulation-based ACLS training, among nursing students in Palestine, using a quasi-experimental design to assess self-efficacy, attitudes, and anxiety; findings again showed significant improvement in self-efficacy after simulation training, with implications for embedding structured, repeated simulation exposure into pre-registration curricula (10) .

The study by Diaz et al. (2020) is done to investigate the effect of simulation-based closed-loop communication (CLC) training on medical errors and staff perceptions of communication ability in a paediatric emergency department. Participants undertook two hands-on CLC simulations one month apart; findings showed improved staff-perceived CLC ability, with implications that structured, repeated rather than single exposure team-communication training is necessary to sustain gains in team-based resuscitation performance. Their review of the wider literature also notes that clear leadership and structured communication are independently associated with better resuscitation task completion, with implications for how team roles should be taught explicitly, alongside the algorithm itself, rather than assumed to develop on their own (6).

Together, these studies show that simulation and structured communication training reliably improve medical students' self-reported knowledge, confidence, and team performance in resuscitation contexts (5,6,10) . What they say, collectively, is that structured, repeated, scaffolded exposure rather than one-off exposure is what sustains improvement in RR and AAM. What this study adds is a lower-resource, classroom-deployable scaffold: rather than relying solely on high-fidelity simulation, it examines whether a colour-coded, step-by-step template, grounded in Cognitive Load Theory, Dual Coding Theory, Scaffolding Theory, and the Zone of Proximal Development, can support the same skills, Rhythm Recognition, Algorithm Application, and Team-Based Performance in a format that can be repeated far more frequently than formal simulation sessions allow.

Conceptual Framework of the Study

Figure 1 illustrates the conceptual framework underpinning this study, in which learners' perceptions of RR and AAM competency are shaped by four interacting instructional dimensions Skills Needed, Teaching Using Colours, Teaching Step-by-Step, and Teaching Using Templates each anchored in a corresponding theory

(Cognitive Load Theory, Dual Coding Theory, Scaffolding Theory, and the Zone of Proximal Development, respectively). The framework positions coloured scaffolds not as a single intervention but as the point at which all four theories converge: colour reduces extraneous load (Sweller, 1988), provides a second encoding channel (Paivio, 1991), marks the steps of the algorithm (Wood et al., 1976), and defines the support structure within the learner's ZPD (Vygotsky, 1978). This conceptual framework guided both the construction of the 27-item survey instrument (Table 2) and the organisation of the Findings section that follows.

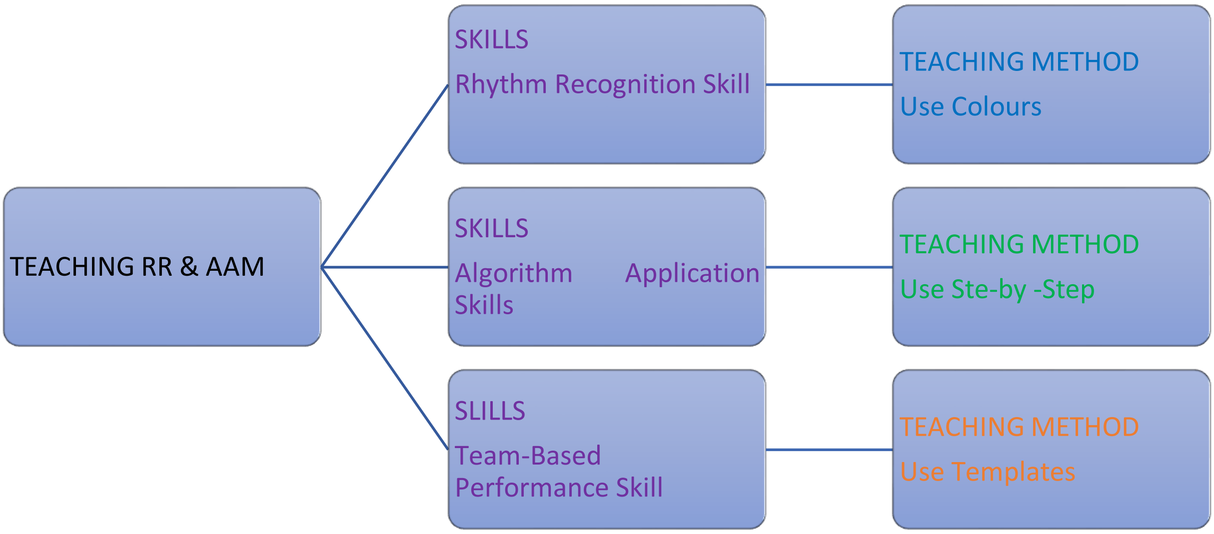

Figure 1- Conceptual Framework of the Study-Perception of learners learning RRM & AAM

METHODOLOGY

This quantitative pilot study is done to explore the use of coloured scaffolds to learn Cardiac Rhythm Recognition and AHA Algorithm-Based Management of Cardiac Emergencies. A convenient sample of 30 participants responded to the survey. The instrument used is a 5-point Likert-scale survey. The formation of the constructs (refer to Table 3) and items in the survey is anchored by four theories: (i) Cognitive Load Theory (Sweller, 1988), (ii) Dual Coding Theory (Paivio, 1991), (iii) Scaffolding Theory (Wood et al., 1976), and (iv) Zone of Proximal Development (Vygotsky, 1978).

Table 1 below shows the categories used for the Likert scale; 1 is for Strongly Disagree, 2 is for Disagree, 3 is for Undecided, 4 is for Agree and 5 is for Strongly Agree.

Table 1 – Likert Scale Use

Value	Frequency
1	Never
2	Rarely
3	Sometimes
4	Often
5	Always

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Table 2 – Distribution of Items in the Survey

Section	Heading/Category Variable	Construct	No. of Items	Total Items (α)
B	Skills Needed for this Topic	Rhythm Recognition Skill	3	
		Algorithm Application Skill	3	
		Team-Based Performance Skill	3	9 (.934)
C	Teaching Using Colours	Memorizing the Rhythm/Pattern Recognition	3	
		Low Frequency and High-Stakes Exposure	3	6 (.802)
D	Teaching Step by Step	Algorithm Taught as a Static Flow Chart	3	
		Less Practice/Skill Decay	3	6 (.901)
E	Teaching Using Templates	Cognitive Narrowing Affecting Rhythm Recognition Under Stress	3	
		Working Memory Overload During Algorithm Execution	3	6 (.899)
	TOTAL		27	27 (.807)

Table 2 shows the distribution of the 27 items in the survey, organised into four sections. Section B (Skills Needed for this Topic) comprises nine items across three constructs, Rhythm Recognition Skill, Algorithm Application Skill, and Team-Based Performance Skill and returned the highest construct reliability (α = .934). Section C (Teaching Using Colours) comprises six items across the Memorizing the Rhythm/Pattern Recognition and Low Frequency and High-Stakes Exposure constructs (α = .802). Section D (Teaching Step-by-Step) comprises six items across the Algorithm Taught as a Static Flow Chart and Less Practice/Skill Decay constructs (α = .901). Section E (Teaching Using Templates) comprises six items across the Cognitive Narrowing Affecting Rhythm Recognition Under Stress and Working Memory Overload During Algorithm Execution constructs (α = .899). Items were adapted and contextualised from established resuscitation-education instruments by Bowers et al. (2020) and Diaz et al. (2020) and mapped directly onto the four anchor theories described in Section 2.1.

Table 3 – Reliability Levels, Cronbach's Alpha Ranges, and Their Interpretations (Ahmad et al. (2024) (11).

Reliability Level	Cronbach's Alpha Range	Interpretation
Excellent	0.9 and above	Indicates very high internal consistency
Good	0.80–0.89	Reflects strong internal consistency
Acceptable	0.70–0.79	Indicates acceptable internal consistency
Questionable	0.60–0.69	Reflects questionable internal consistency
Poor	Below 0.6	Indicates poor internal consistency

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E	Teaching Using Templates	Cognitive narrowing affecting rhythm recognition under stress	3	6(.899)
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Table 2 also shows the reliability of the survey. The analysis shows a Cronbach's alpha (refer to Table 3 for Cronbach analysis distribution) of .934 for Skills, .802 for Colours, .901 for Step-by-Step, and .899 for Templates. The overall Cronbach Alpha for all 27 items is .807; thus, revealing a good reliability of the instrument chosen/used. Further analysis using SPSS is done to present findings to answer the research questions for this study.

FINDINGS

Demographic Analysis

According to Ziegenfuss et al. (2021), researchers report demographic data in percentages to establish sample representativeness and allow for generalizability to a larger population. The reporting also provides an overview of participants' characteristics; percentages offer a clear and understandable picture of the sample makeup (12).

Table 4- Percentage for Demographic Profile

Question	Demographic Profile	Categories	Percentage (%)
1	Gender	Male	32%
		Female	68%
2	Year of Study	Final Year	100%
3	Clinical Rotation	Emergency Medicine	100%

Table 4 shows that the sample was predominantly female (68%) compared to male (32%). All respondents (100%) were final-year undergraduate medical students undergoing their Emergency Medicine clinical rotation at the time of data collection. This homogeneous sampling frame means the findings reported below reflect the perceptions of a single, well-defined cohort final-year students with direct, concurrent clinical exposure to cardiac emergencies through their Emergency Medicine posting rather than a cross-section of students at varying stages of the curriculum.

Descriptive Statistics

Why is there a need to report the mean and standard deviation? According to Vetter et al. (2017), Mean (M) represents the average, or centre of a data set. Standard deviation (SD) indicates the typical distance of individual observations from the mean which shows the data's variability or spread. A low SD means the data points are clustered close to the mean, while a high SD indicates they are more spread out, reflecting greater variability in respondents' perception (13).

Findings for Skills

This section presents data to answer research Question 1: How do learners perceive their skills in learning? In the context of this study, this is measured by (i) Rhythm Recognition Skill and (ii) Algorithm Application Skill, and (iii) Team-Based Resuscitation Performance Skill.

Table 5- Mean (M) and Standard Deviation (SD) for Rhythm Recognition Skill

NO	ITEM/INDICATOR	M	SD
1	B1 I can differentiate shockable (VF/pulseless VT) from non-shockable (asystole/PEA) rhythms.	3.63	1.19
2	B2 I can identify life-threatening bradyarrhythmias (example: complete heart block) on the monitor.	3.20	1.19
3	B3 I can recognise rhythm changes in real time during an evolving cardiac emergency.	3.27	1.11

Table 5 shows that respondents rated their ability to select the correct drug and dose at the correct algorithm timepoint most highly among related items, while identifying life-threatening bradyarrhythmias such as complete heart block (B2, M = 3.20, SD = 1.19) was rated lowest, and differentiating shockable from non-shockable rhythms (B1, M = 3.63, SD = 1.19) was rated highest within this table. This pattern suggests students feel more confident with visually distinctive, frequently drilled rhythms than with less common ones, consistent with Cognitive Load Theory's (Sweller, 1988) view that unfamiliar, low-frequency stimuli impose a higher intrinsic load than familiar, well-rehearsed ones (1).

Table 6- Mean (M) and Standard Deviation (SD) for ACLS Algorithm Application Skill

NO	ITEM/INDICATOR	M	SD
1	B4 I can follow the correct sequence of the ACLS cardiac arrest algorithm without prompting.	3.53	1.11
2	B5 I can select the correct drug and dose at the correct algorithm timepoint (example: adrenaline every 3–5 min).	3.70	1.02

3	B6 I can correctly time the shock – CPR – rhythm check cycle without deviating from the algorithm.	3.70	0.95

Table 6 shows a similar pattern for ACLS Algorithm Application Skill, with the highest means recorded for correct drug/dose timing (B5, M = 3.70) and shock–CPR–rhythm cycle timing (B6, M = 3.70), and the lowest for following the correct sequence of the algorithm without prompting (B4, M = 3.53). Although all three items were rated above the scale midpoint, the close clustering of means suggests students perceive the entire algorithmic sequence, rather than any single step, as the main source of difficulty and is consistent with the working-memory bottleneck described by Szulewski et al. (2021) when multiple algorithm branches must be held in mind simultaneously (2).

Table 7- Mean (M) and Standard Deviation (SD) for Team-Based Resuscitation Performance Skill

NO	ITEM/INDICATOR	M	SD
1	B7 I can lead a resuscitation team, assigning roles clearly during a cardiac arrest scenario.	3.20	1.21
2	B8 I can give closed-loop communication instructions clearly to team members during resuscitation.	3.33	1.15
3	B9 I can maintain high-quality chest compressions and coordinate role switches without interrupting CPR flow.	4.03	0.96

Table 7 shows that Team-Based Resuscitation Performance was rated lowest overall among the three Skills constructs, with leading a resuscitation team and assigning roles clearly (B7, M = 3.20, SD = 1.21) the most difficult item, followed by giving closed-loop communication instructions (B8, M = 3.33, SD = 1.15). Maintaining high-quality chest compressions while coordinating role switches (B9, M = 4.03, SD = 0.96) was, by contrast, rated as a relative strength. This gap between technical/motor performance (B9) and leadership/communication performance (B7, B8) mirrors Diaz et al. (2020), who similarly found that closed-loop communication required more deliberate, repeated practice than psychomotor resuscitation skills to reach comparable proficiency (6).

Findings for Teaching Using Colours

This section presents data to answer Research Question 2: How do learners perceive learning through colours? In the context of this study, this is measured by (i) Memorizing the rhythm / Pattern Recognition, (ii) Low Frequency and High Stakes Exposure.

Table 8- Mean (M) and Standard Deviation (SD) for Memorizing the rhythm / Pattern Recognition

NO	ITEM/INDICATOR	M	SD
1	C1 I find it difficult to recall the distinguishing features of each rhythm from memory alone.	3.17	1.15
2	C2 I confuse similar-looking rhythms (example: VT vs. SVT with aberrancy) under time pressure.	3.37	1.30
3	C3 I rely on a reference chart/cheat sheet to identify rhythms rather than recognising them instantly.	3.27	1.01

Table 8 shows that students most strongly agreed that they confuse similar-looking rhythms such as VT and SVT with aberrancy under time pressure (C2, M = 3.37, SD = 1.30), and that they rely on a reference chart rather than recognising rhythms instantly (C3, M = 3.27, SD = 1.01). Difficulty recalling distinguishing features from memory alone (C1, M = 3.17, SD = 1.15) was rated slightly lower but still above the scale midpoint. These results support the Dual Coding Theory (Paivio, 1991) rationale for colour scaffolding, since reliance on an external reference chart suggests that verbal/textual encoding alone is insufficient for rapid rhythm recall (3).

Table 9- Mean (M) and Standard Deviation (SD) for Low Frequency and High Stakes Exposure

NO	ITEM/INDICATOR	M	SD
1	C4 I rarely encounter real cardiac arrest rhythms during my clinical placements.	3.10	1.06
2	C5 My confidence in rhythm recognition drops when the situation feels high-stakes or urgent.	3.27	0.87
3	C6 I have not had enough repeated practice opportunities to build automatic rhythm recognition.	3.37	1.22

Table 9 shows that not having had enough repeated practice opportunities to build automatic rhythm recognition (C6, M = 3.37, SD = 1.22) was the most prominent concern, followed by a drop in confidence in high-stakes situations (C5, M = 3.27, SD = 0.87) and rarely encountering real cardiac arrest rhythms during clinical placements (C4, M = 3.10, SD = 1.06). These findings reinforce the low-frequency, high-stakes exposure problem that coloured, repeatable scaffolds are intended to address, since such templates can be practised far more often than real or simulated cardiac arrests occur.

Findings for Step-by-Step

This section presents data to answer Research Question 3: How do learners perceive learning step-by-step? In the context of this study, this is measured by (i) Algorithm Taught as a Static Flow Chart, and (ii) Less Practice / Skill Decay.

Table 10- Mean (M) and Standard Deviation (SD) for Algorithm Taught as a Static Flow Chart

NO	ITEM/INDICATOR	M	SD
1	D1 I was mainly taught the AHA algorithm as a diagram/flow chart rather than through hands-on practice	3.07	0.94
2	D2 I can recite the algorithm steps on paper but struggle to apply them in a dynamic scenario.	3.37	0.89
3	D3 The way the algorithm was taught did not prepare me for making decisions under time pressure.	3.17	1.09

Table 10 shows that students agreed most strongly that they can recite the algorithm steps on paper but struggle to apply them in a dynamic scenario (D2, M = 3.37, SD = 0.89), followed by the perception that the way the algorithm was taught did not prepare them for decision-making under time pressure (D3, M = 3.17, SD = 1.09), and that they were mainly taught the algorithm as a static diagram rather than through hands-on practice (D1, M = 3.07, SD = 0.94). This pattern is consistent with Young et al.'s (2014) observation that static instructional formats support declarative recall but do not, on their own, build the procedural fluency required for real-time application (8)

Table 11- Mean (M) and Standard Deviation (SD) for Less Practice / Skill Decay

NO	ITEM/INDICATOR	M	SD
1	D4 I have had limited opportunities to rehearse the full algorithm in a simulated cardiac arrest.	3.17	1.9
2	D5 My skill in applying the algorithm declines noticeably between training sessions.	2.93	1.14
3	D6 I have not received enough repeat simulation sessions to make the algorithm feel automatic.	3.23	1.22

Table 11 shows that insufficient repeat simulation sessions to make the algorithm feel automatic (D6, M = 3.23, SD = 1.22) and limited opportunities to rehearse the full algorithm (D4, M = 3.17, SD = 1.90) were both rated above the midpoint, while skill decline between training sessions (D5, M = 2.93, SD = 1.14) was rated comparatively lower. Overall, these results echo Diaz et al.'s (2020) call for structured, low-resource tools that can be used between formal simulation sessions to slow the decay of algorithm fluency (6).

Findings for Templates

This section presents data to answer research Question 4: How do learners perceive learning through templates? In the context of this study, this is measured by (i) Cognitive Narrowing Affecting Rhythm Recognition Under Stress, and (ii) Working Memory Overload During Algorithm Execution.

Table 12- Mean (M) and Standard Deviation (SD) for Cognitive Narrowing Affecting Rhythm Recognition Under Stress

NO	ITEM/INDICATOR	M	SD
1	E1 I can identify rhythms correctly on a slide/quiz but struggle to do so during a live scenario.	3.33	0.92
2	E2 My ability to focus on the monitor decreases when I am also managing other tasks during a scenario.	3.23	0.94
3	E3 Stress during a simulated emergency makes me second-guess rhythms I would normally recognise easily.	3.27	0.78

Table 12 shows that students most strongly agreed that they can identify rhythms correctly on a slide or quiz but struggle to do so during a live scenario (E1, M = 3.33, SD = 0.92), consistent with reduced ability to focus on the monitor while managing other tasks (E2, M = 3.23, SD = 0.94) and second-guessing rhythms they would normally recognise easily under stress (E3, M = 3.27, SD = 0.78). This gap between static and live-scenario performance is precisely the transfer problem coloured, template-based scaffolds are designed to narrow, by rehearsing the same colour cues across both static and dynamic practice formats.

Table 13- Mean (M) and Standard Deviation (SD) for Working Memory Overload During Algorithm Execution

NO	ITEM/INDICATOR	M	SD
1	E4 I lose track of the next algorithm step when multiple things are happening at once (compressions, drugs, airway).	3.33	0.88
2	E5 I find it hard to keep track of time (e.g. 2-minute cycles, drug timing) while also managing the rhythm and team.	3.03	1.03
3	E6 I make more errors in the algorithm sequence when I am also expected to lead the team.	3.17	0.87

Table 13 shows that losing track of the next algorithm step amid competing demands (E4, M = 3.33, SD = 0.88) was rated the most prominent concern, followed by difficulty keeping track of time while also managing the rhythm and team (E5, M = 3.03, SD = 1.03), and making more errors in the algorithm sequence when expected to lead the team (E6, M = 3.17, SD = 0.87). Taken together, these ratings confirm that working memory overload remains a consistent, above-midpoint concern across the sample, aligning with the Cognitive Load Theory rationale (Sweller, 1988) for reducing extraneous load through colour-coded scaffolding (1).

CONCLUSION

Summary of Findings and Discussions

Across all four research questions, the pilot data suggest that students are most confident in well-rehearsed, protocolised, and psychomotor components of RR and AAM (example: drug and timing sequencing, B5–B6; chest compression coordination, B9), and least confident in components that require rapid discrimination under time pressure, leadership and communication, or transfer from static to live scenarios (B7, B8, C2, D2, E1). The overall pattern is one of a transfer gap between declarative/static knowledge and dynamic, high-stakes performance. The gap that coloured, step-by-step, template-based scaffolding is theorised to narrow.

Skills

In general, this study found that students perceived their team-based leadership and communication skills as weaker than their technical/psychomotor and drug-timing skills. This finding is in accordance with the study by Diaz et al. (2020), who similarly found that closed-loop communication required more deliberate, repeated practice than psychomotor skills to reach comparable proficiency (6).

Teaching Using Colours

In general, this study found that students rely heavily on external reference charts rather than automatic recall, and confuse visually similar rhythms under pressure. This finding is in accordance with Paivio's (1991) Dual Coding Theory and Mayer and Sims's (1994) finding that well-matched visual–verbal pairing improves retention of complex procedural material, supporting the use of colour as a genuine second retrieval channel rather than a purely decorative device (3,7).

Teaching Step-by-Step

In general, this study found that students can recite algorithm steps on paper but struggle to apply them dynamically, and feel under-prepared for decision-making under time pressure. This finding is in accordance with Young et al.'s (2014) observation that static instructional formats support declarative recall but not procedural fluency, and with Wood et al.'s (1976) scaffolding principle that a task must be broken into supported, sequenced steps before independent performance is possible (4,8).

Teaching using Templates

In general, this study found that students experience a marked drop-off between static/quiz-based rhythm identification and live-scenario performance, consistent with cognitive narrowing and working-memory overload. This finding is in accordance with Vygotsky's (1978) Zone of Proximal Development, in that templates appear most valuable precisely at the point where the task exceeds the learner's unassisted working-memory capacity (9) .

Implications and Suggestions for Future Research

Theoretical and Conceptual Implications

The findings lend general support to the four-theory conceptual framework in Section 2.3: Cognitive Load Theory is supported by the consistently elevated working-memory-overload ratings (Table 13); Dual Coding Theory is supported by students' reliance on external references over automatic recall (Table 8); Scaffolding Theory is supported by the gap between step-by-step recitation and dynamic application (Table 10); and the Zone of Proximal Development is supported by the transfer gap between static and live-scenario performance (Table 12). Together, these results suggest the four theories operate cumulatively rather than independently, each addressing a different point of failure along the same skill-acquisition pathway.

Pedagogical Implications

These findings suggest that undergraduate RR and AAM teaching should not rely solely on static flow charts or infrequent high-fidelity simulation, but should incorporate a repeatable, colour-coded, template-based scaffold that students can use between formal simulation sessions to counter the skill decay and low-frequency exposure identified in Tables 9 and 11. Particular attention should be given to team leadership and closed-loop communication (Table 7), which this pilot sample rated as a comparative weakness relative to technical and psychomotor performance.

Suggestions for Future Research

Future researchers should look into a controlled, comparative study (coloured scaffold versus conventional flow chart) with a larger, multi-centre sample, to establish whether the perception gains reported here translate into measurable improvements in rhythm-recognition accuracy and algorithm adherence. Future work should also consider objective performance measures for example, video-rated simulation scoring alongside the self-report data used in this pilot.

Limitations of the Study

This pilot study has several limitations that should be considered when interpreting the findings. The sample comprised a convenience sample of 30 final-year students from a single institution, all drawn from the same clinical rotation, which limits generalisability and may introduce selection bias. All data were self-reported perceptions rather than objective measures of rhythm-recognition accuracy or algorithm adherence; accordingly, the findings should be read as reflecting perceived rather than actual competence. The 27-item instrument, while internally reliable (Cronbach's $\alpha = .807$), has not yet been validated against external criteria or through test-retest reliability. The demographic data collected were limited and did not allow exploration of whether perceptions varied by prior resuscitation training or previous simulation experience. Finally, the study did not include a comparison group (for example, conventional teaching versus coloured scaffolds), so the specific contribution of the scaffold itself cannot be isolated from other components of teaching. Given these limitations, the findings should be treated as hypothesis-generating rather than confirmatory, and interpreted accordingly pending the controlled, comparative follow-up study proposed in Section 5.2.3.

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APPENDIX A

Survey Instrument

The full 27-item survey instrument used in this study, together with the demographic questions, is reproduced below.

Participation was anonymous and voluntary, and responses were used only for course improvement and research purposes. Respondents rated each item on a 5-point Likert-type frequency scale: 1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, 5 = Always.

Section A – Demographic Profile

A1 Gender (Male / Female)

A2 Year of Study

A3 Clinical Rotation

Section B – Skills Needed for this Topic

B1 I can differentiate shockable (VF/pulseless VT) from non-shockable (asystole/PEA) rhythms.

B2 I can identify life-threatening bradyarrhythmias (example: complete heart block) on the monitor.

B3 I can recognise rhythm changes in real time during an evolving cardiac emergency.

B4 I can follow the correct sequence of the ACLS cardiac arrest algorithm without prompting.

B5 I can select the correct drug and dose at the correct algorithm timepoint (example: adrenaline every 3–5 min).

B6 I can correctly time the shock – CPR – rhythm check cycle without deviating from the algorithm.

B7 I can lead a resuscitation team, assigning roles clearly during a cardiac arrest scenario.

B8 I can give closed-loop communication instructions clearly to team members during resuscitation.

B9 I can maintain high-quality chest compressions and coordinate role switches without interrupting CPR flow.

Section C – Teaching Using Colours

C1 I find it difficult to recall the distinguishing features of each rhythm from memory alone.

C2 I confuse similar-looking rhythms (example: VT vs. SVT with aberrancy) under time pressure.

C3 I rely on a reference chart/cheat sheet to identify rhythms rather than recognising them instantly.

C4 I rarely encounter real cardiac arrest rhythms during my clinical placements.

C5 My confidence in rhythm recognition drops when the situation feels high-stakes or urgent.

C6 I have not had enough repeated practice opportunities to build automatic rhythm recognition.

Section D – Teaching Step by Step

D1 I was mainly taught the AHA algorithm as a diagram/flow chart rather than through hands-on practice.

D2 I can recite the algorithm steps on paper but struggle to apply them in a dynamic scenario.

D3 The way the algorithm was taught did not prepare me for making decisions under time pressure.

D4 I have had limited opportunities to rehearse the full algorithm in a simulated cardiac arrest.

D5 My skill in applying the algorithm declines noticeably between training sessions.

D6 I have not received enough repeat simulation sessions to make the algorithm feel automatic.

Section E – Teaching Using Templates

E1 I can identify rhythms correctly on a slide/quiz but struggle to do so during a live scenario.

E2 My ability to focus on the monitor decreases when I am also managing other tasks during a scenario.

E3 Stress during a simulated emergency makes me second-guess rhythms I would normally recognise easily.

E4 I lose track of the next algorithm step when multiple things are happening at once (compressions, drugs, airway).

E5 I find it hard to keep track of time (e.g. 2-minute cycles, drug timing) while also managing the rhythm and team.

E6 I make more errors in the algorithm sequence when I am also expected to lead the team.