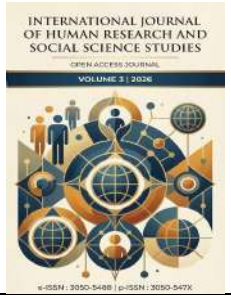
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Exploiting Digital Tools in Teaching the Light Topic in Grade 9 Natural Science: A Survey of Lower Secondary School Teachers

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ABSTRACT: This study examines how lower secondary school teachers use digital tools when teaching the Light topic in Grade 9 Natural Science. Data were collected from 50 teachers through a 16-item questionnaire that included four scales, with Cronbach's α ranging from 0.848 to 0.956. All teachers reported using digital tools, and the mean frequency across nine instructional functions was 3.62 on a five-point scale. Interactive simulations were used by 90.0% of teachers when teaching Light. However, 64.0% of teachers reported that students mainly watched content projected by the teacher, and the functions of data processing, explanation and application, and assessment were used less often than visualisation. The most frequently reported difficulties in teaching Light were that simulations were hard to operate or did not show the nature of the phenomena clearly (56.0%) and that simulations were difficult to combine with hands-on optics experiments (48.0%). The findings suggest that teacher professional development should focus on designing tasks in which students investigate with simulations, work with quantitative data, and link simulations with ray diagrams and real experiments.

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1. INTRODUCTION

The 2018 General Education Curriculum in Vietnam assigns Natural Science at lower secondary level the task of developing students' natural science competence, including the competence to inquire into the natural world (Ministry of Education and Training [MOET], 2018). In 2025, MOET issued the Digital Competence Framework for Learners, which comprises six competence areas, among them information and data exploitation and problem solving (MOET, 2025). The framework has a structure similar to the European DigComp 2.2 framework (Vuorikari et al., 2022). Together, these documents require Natural Science teachers to use digital tools to present content and, at the same time, to create opportunities for students to develop digital competence while learning the subject.

The Light topic in Grade 9 Natural Science covers reflection, refraction, prisms and dispersion of light, and converging and diverging lenses. Light rays are model-based entities that students cannot observe directly in many situations, while optics experiments in the classroom depend on equipment and lighting conditions. Interactive simulations such as PhET allow students to change parameters and observe the results immediately (Wieman et al., 2008), and virtual laboratories allow experiments to be repeated many times and make visible what is difficult to observe in a physical laboratory (de Jong et al., 2013). Light is therefore a suitable topic for examining how teachers exploit digital tools.

In Vietnam, several studies have proposed and tested ways of using virtual experiments and simulations in teaching Physics and Natural Science. Trần et al. (2021) developed a procedure for using a virtual laboratory in teaching the chapter "Gases" in Grade 10 Physics. Nguyễn (2025) proposed using PhET simulations within the Generate, Evaluate, Modify (GEM) learning cycle in Natural Science. T. H. N. Võ et al. (2025) combined simulated and real experiments in inquiry-based teaching and reported that

students in the experimental class worked more independently when assembling circuits and investigating phenomena. These studies mainly propose procedures and test them on a single topic. Data on how teachers currently use digital tools in a specific topic, how students participate when the tools are used, and what difficulties teachers face remain limited.

This study examines the current use of digital tools in teaching the Light topic in Grade 9 Natural Science from the perspective of lower secondary school teachers. It addresses three research questions: (1) For which instructional functions, and how often, do teachers use digital tools, particularly when teaching Light? (2) At what level do students participate when digital tools are used, and how do teachers rate the opportunities for students to develop digital competence? (3) What difficulties do teachers face and what support do they need?

2. THEORETICAL FRAMEWORK

In Natural Science teaching, digital tools can serve several functions. This study considers nine: visualising and representing knowledge; simulating and investigating phenomena; experimenting and collecting data; processing and analysing data; constructing and verifying knowledge; explaining and applying; interacting and collaborating; assessing and giving feedback; and supporting self-study. The first group of functions focuses on representing phenomena for students to observe. The second group requires students to process information, reason, or exchange ideas with others. The same tool, for example a refraction simulation, may serve visualisation when the teacher projects it, or investigation and verification when students change the angle of incidence themselves, record data and derive a rule.

To describe student engagement, the study draws on the ICAP framework (Chi & Wylie, 2014). The framework distinguishes four modes based on observable behaviour: passive (receiving information), active (manipulating learning materials), constructive (generating outputs beyond the information provided, such as predictions, explanations or conclusions) and interactive (co-constructing through dialogue). According to Chi and Wylie (2014), understanding tends to increase from the passive to the interactive mode. Applied to the use of digital tools, students watching content projected by the teacher correspond to the passive mode; students following instructions or changing parameters correspond to the active mode; and students proposing predictions, analysing data and using results as evidence correspond to the constructive mode. The mode of engagement therefore depends more on the task the teacher sets than on the tool itself.

Regarding digital competence, the Digital Competence Framework for Learners identifies information and data exploitation and problem solving as two of its six areas (MOET, 2025); these correspond to information and data literacy and problem solving in DigComp 2.2 (Vuorikari et al., 2022). In Natural Science, the first area is reflected in students searching for, collecting and organising data and evaluating its reliability; the second is reflected in students identifying tasks, selecting tools, adjusting their approach and using results as evidence. The study operationalised these two areas as 11 indicators for teachers to rate the extent to which the use of digital tools creates opportunities for students.

Learning about light involves at least three forms of representation: simulations, ray diagrams and real optics experiments. de Jong et al. (2013) argued that physical and virtual laboratories have different affordances and that their combination needs to be designed deliberately. The results of T. H. N. Võ et al. (2025) on resistance and Ohm's law also indicate that such a combination supports students in investigation. The extent to which teachers link these representations is thus one aspect to consider when describing current practice.

Teachers' use of digital tools is shaped by various conditions. Ertmer (1999) distinguished first-order barriers, which are external conditions such as equipment, time, training and support, from second-order barriers, which are teachers' beliefs and teaching routines. C. N. Võ et al. (2026) reviewed the competence of lower secondary Natural Science teachers and grouped it into four areas: subject and integrated knowledge, instructional design, assessment, and professional development. At university level, Lê (2026) found that lecturers' digital skills were fairly good but weaker in using technology for assessment and learner management, and that the uptake of new technologies depended largely on individual initiative. These perspectives frame the analysis of teachers' difficulties and support needs in this study.

3. METHOD

The study used a cross-sectional survey design. Data were collected with a teacher questionnaire of 16 items in six parts: general information; use of digital tools in Natural Science teaching; opportunities for students to develop digital competence; use of digital tools in teaching Light; difficulties and support needs; and additional comments. The questionnaire contained four scales: nine instructional functions (five points, from "Never used" to "Very often"); five indicators of information and data exploitation and six indicators of problem solving (five points, from "Almost no opportunity" to "Very many opportunities"); and ten activities in teaching Light (four points, from "Never used" to "Often"). The indicators of the second and third scales were derived from the two corresponding areas of the Digital Competence Framework for Learners (MOET, 2025); these two scales also offered the option "Not enough experience to rate", and the fourth scale offered "No conditions to use". The remaining items were single-choice, multiple-choice and one open-ended question asking teachers to describe a concrete example of using digital tools in teaching Light.

The questionnaire was administered online from 17 to 23 October 2026 using convenience sampling, and 50 lower secondary Natural Science teachers responded. Of those who reported their teaching experience (n = 49), 12.2% had taught for less than 2 years, 26.5% for 2 to under 5 years, 36.7% for 5 to under 10 years and 24.5% for 10 years or more; 68.8% of teachers (n = 48) regularly taught Physics-related topics. Participation was voluntary, and the questionnaire informed teachers that their responses would be used only for research purposes and kept confidential.

Data were coded and analysed in JASP. The reliability of the four scales was estimated with Cronbach's α and McDonald's ω (Hayes & Coutts, 2020). All four scales exceeded the 0.70 threshold (Taber, 2018), with α (ω) of 0.924 (0.924), 0.848 (0.851), 0.882 (0.896) and 0.956 (0.956), respectively. Item means (*M*) and standard deviations (*SD*) were computed from the frequency distributions and interpreted using equal intervals, with an interval width of (maximum − minimum)/number of levels: on the five-point scales, level 3 corresponds to 2.61 to 3.40 and level 4 to 3.41 to 4.20; on the four-point scale, "Sometimes" corresponds to 2.51 to 3.25 and "Often" to 3.26 to 4.00. Blank responses and multiple selections on single-choice items were treated as missing; percentages for multiple-choice items were calculated on valid responses. The open-ended question was analysed through content analysis: 17 substantive comments were grouped into themes and compared with the quantitative results.

4. RESULTS

4.1. Use of digital tools by instructional function

All 50 teachers had used digital tools in Natural Science teaching: 58.0% used them often, 36.0% sometimes, and 6.0% only when illustration was needed. Table 1 presents the frequency of use across the nine instructional functions.

Table 1. Frequency of digital tool use by instructional function

No.	Instructional function	Rarely (%)	Sometimes (%)	Often (%)	M	SD
1	Visualising and representing knowledge	0.0	26.0	74.0	3.74	0.44
2	Simulating and investigating phenomena (n = 49)	2.0	32.7	65.3	3.63	0.53
3	Experimenting and collecting data	0.0	36.0	64.0	3.64	0.48
4	Processing and analysing data (n = 49)	0.0	42.9	57.1	3.57	0.50
5	Constructing and verifying knowledge	0.0	28.0	72.0	3.72	0.45
6	Explaining and applying	0.0	44.0	56.0	3.56	0.50
7	Interacting and collaborating	0.0	44.0	56.0	3.56	0.50
8	Assessing and giving feedback	0.0	42.0	58.0	3.58	0.50
9	Supporting self-study	0.0	42.0	58.0	3.58	0.50
	Overall mean				**3.62**	**0.39**

The means of the nine functions ranged from 3.56 to 3.74, all at the "Often" level, with a difference of 0.18 between the highest and lowest. In terms of the proportion of teachers selecting "Often", functions related to representing and observing phenomena had higher proportions: visualising (74.0%), constructing and verifying knowledge (72.0%), simulating and investigating (65.3%) and experimenting (64.0%). Functions requiring students to process information, reason or exchange ideas had proportions of 56.0% to 58.0%.

4.2. Types of digital tools and student engagement

Figure 1a shows that interactive simulations of optical phenomena were the most widely used tool when teaching Light (90.0%). Data measurement, collection and processing tools had the lowest proportion among the tool types (16.0%), and AI tools for designing materials and questions were used by 34.0% of teachers.

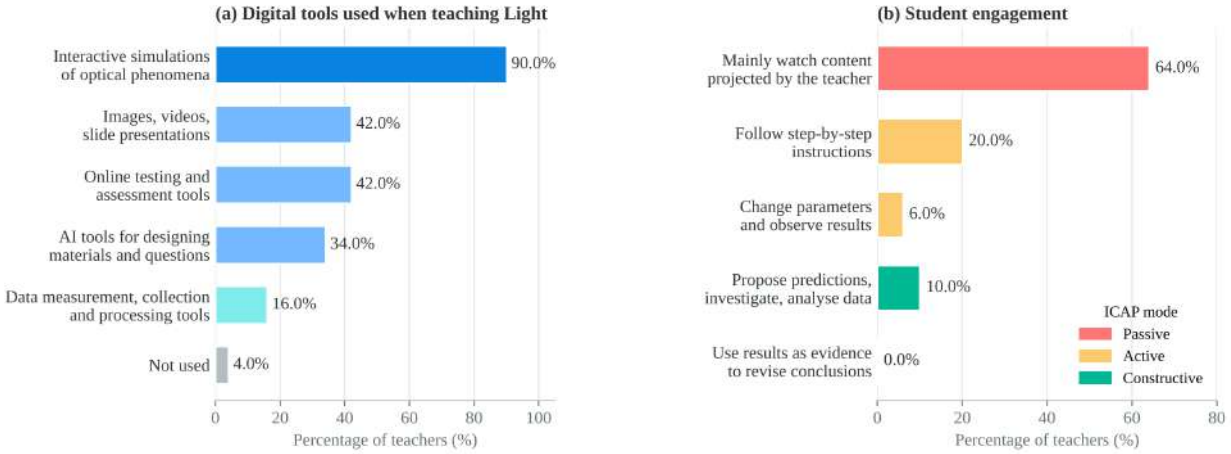


Figure 1. Digital tools used when teaching Light (a) and student engagement when digital tools are used (b) (n = 50)

Figure 1b shows that 64.0% of teachers reported that students mainly watched content projected by the teacher. In ICAP terms, 64.0% of teachers described student engagement in the passive mode, 26.0% in the active mode and 10.0% in the constructive mode; no teacher selected the level at which students use results as evidence to revise conclusions. This differs from the 72.0% of teachers who reported often "organising students to make predictions, test them and draw conclusions" in Table 1. Regarding the ways digital tools support students, 92.0% of teachers selected "visualising light paths and phenomena that are hard to observe directly", 74.0% "explaining phenomena based on evidence", 38.0% "testing predictions and correcting misconceptions" and 24.0% "practising, consolidating and self-assessing".

4.3. Use of digital tools in teaching Light

Reflection and refraction were the contents most teachers had taught (84.0% each), followed by prisms and dispersion (72.0%) and lenses (58.0%); 6.0% of teachers had not yet taught the Grade 9 Light topic. Table 2 presents the frequency of digital tool use for ten activities in teaching Light.

Table 2. Frequency of digital tool use in teaching Light (n = 50)

No.	Activity	Never used (%)	Rarely (%)	Sometimes (%)	Often (%)	M	SD
1	Illustrating light paths and optical phenomena	2.0	0.0	20.0	78.0	3.74	0.56
2	Letting students change the angle of incidence, medium or conditions	2.0	0.0	32.0	66.0	3.62	0.60
3	Simulating light through a prism and dispersion	2.0	0.0	26.0	72.0	3.68	0.59
4	Letting students change object position, focal length or lens type to investigate image formation	2.0	2.0	48.0	48.0	3.42	0.64
5	Guiding students to draw and read ray diagrams and compare them with simulations	2.0	0.0	32.0	66.0	3.62	0.60
6	Having students predict before operating or observing	2.0	0.0	20.0	78.0	3.74	0.56
7	Guiding students to compare results and derive optical rules	2.0	0.0	24.0	74.0	3.70	0.58
8	Asking students to use results as evidence to explain and defend conclusions	2.0	0.0	26.0	72.0	3.68	0.59
9	Comparing simulations with real experiments and examining discrepancies	2.0	0.0	30.0	68.0	3.64	0.60
10	Checking understanding and detecting errors about light paths and image formation	2.0	0.0	36.0	62.0	3.58	0.61
	Overall mean					**3.64**	**0.50**

The overall mean of the scale was 3.64 (*SD* = 0.50), at the "Often" level. The two activities with the highest proportion of "Often" were illustrating light paths and having students predict before observing (78.0% each). The activity of letting students change object position, focal length and lens type to investigate image formation had the lowest mean (*M* = 3.42), with equal proportions of "Sometimes" and "Often" (48.0% each). Activities in which students operate simulations themselves had lower proportions of "Often" than illustration by the teacher (66.0% and 48.0% compared with 78.0%).

4.4. Opportunities for students to develop digital competence

Table 3 presents teachers' ratings of the extent to which the use of digital tools creates opportunities for students to develop the two areas of digital competence.

Table 3. Teachers' ratings of opportunities for students to develop digital competence (n = 50)

No.	Indicator	Levels 1–2 (%)	Level 3 (%)	Level 4 (%)	Level 5 (%)	M	SD
A. Information and data exploitation						**3.70**	**0.40**
A1	Searching for and selecting digital data and information relevant to a Physics task	2.0	12.0	86.0	0.0	3.84	0.42
A2	Collecting, recording and storing data from simulations, videos or experiments	0.0	20.0	80.0	0.0	3.80	0.40
A3	Organising data into tables and graphs	2.0	30.0	68.0	0.0	3.64	0.60
A4	Comparing data, evaluating reliability and identifying anomalies	2.0	38.0	60.0	0.0	3.58	0.54
A5	Identifying patterns and evaluating fit with predictions or models	2.0	32.0	66.0	0.0	3.64	0.53
B. Problem solving with digital technology						**3.65**	**0.46**
B1	Identifying the task and selecting an appropriate digital tool	2.0	24.0	74.0	0.0	3.72	0.50
B2	Changing parameters, trying alternatives and repeating investigations	0.0	30.0	70.0	0.0	3.70	0.46
B3	Detecting and resolving difficulties with software or devices	2.0	38.0	56.0	4.0	3.62	0.60
B4	Combining digital tools with real experiments, diagrams or models	4.0	36.0	56.0	4.0	3.60	0.64
B5	Using investigation results as evidence to verify and explain	2.0	38.0	56.0	4.0	3.62	0.60
B6	Recognising limitations and improving the use of digital tools	4.0	30.0	62.0	4.0	3.66	0.63

The means of the 11 indicators ranged from 3.58 to 3.84, at the level of "many opportunities"; information and data exploitation (*M* = 3.70) was rated higher than problem solving (*M* = 3.65). Within each area, indicators at the early stages of the process (searching for and collecting information; identifying the task and changing parameters) had higher means than indicators requiring evaluation and reasoning (evaluating data reliability; combining with real experiments; using results as evidence). When asked which activities created the clearest opportunities (up to three choices), 78.0% of teachers selected "collecting, organising, representing and analysing experimental data", 50.0% "comparing simulation results with real experiments or scientific models", 40.0% "selecting tools or investigation plans", 30.0% "changing simulation parameters for controlled investigation" and 24.0% "using data and evidence to explain and verify".

4.5. Difficulties and support needs

Table 4 places the general difficulties in using digital tools in Natural Science teaching alongside the support needs with corresponding content; the pairs were matched by content.

Table 4. General difficulties and support needs of teachers

Area	Difficulty	% (n = 50)	Support need	% (n = 49)
Infrastructure	Lack of devices, Internet connection or conditions for students to use devices	74.0	Additional devices, connectivity and conditions for teaching	71.4
Combining with real experiments	Difficult to combine digital tools with real experiments	66.0	Guidance on combining simulations with real experiments	73.5
Teacher skills	Not proficient in operating tools or lack of preparation time	34.0	Training in using appropriate digital tools	85.7
Assessment	Difficult to assess students' understanding and competence through digital products	34.0	Guidance on assessing learning outcomes and competence	51.0
Organising activities	Difficult to organise and monitor student activities with digital devices	22.0	Sample learning tasks linked to each instructional function	81.6
Digital materials	Difficult to find or evaluate the scientific accuracy of materials and simulations	18.0	A list of materials and simulations checked for scientific accuracy	69.4

The two most frequently selected difficulties were the lack of devices and connectivity (74.0%) and the difficulty of combining digital tools with real experiments (66.0%). Difficulties related to skills, assessment, organisation of activities and materials were selected by 18.0% to 34.0% of teachers. In contrast, the most frequently selected needs were training in skills (85.7%) and sample learning tasks (81.6%). Figure 2 presents the difficulties specific to using digital tools in teaching Light.

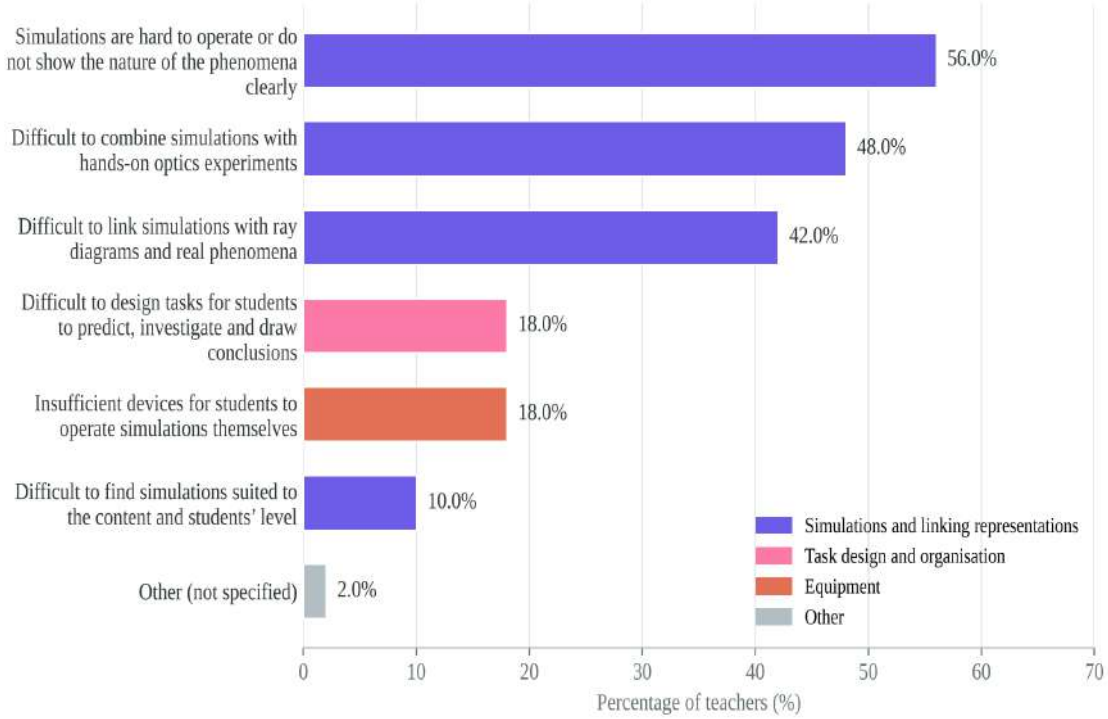


Figure 2. Teachers' difficulties in using digital tools to teach Light (n = 50)

The three most frequently selected difficulties all concerned simulations and their relationship with other representations: simulations were hard to operate or did not show the nature of the phenomena clearly (56.0%), it was difficult to combine simulations with hands-on optics experiments (48.0%), and it was difficult to link simulations with ray diagrams and real phenomena (42.0%). Difficulty in finding simulations was selected by only 10.0% of teachers. Among the 17 substantive comments to the open-ended question, the most frequent theme was managing students when they operated devices themselves (5 comments), for example:

"When students operate computers by themselves, they are easily distracted by extra features or built-in games, making it difficult for the teacher to track the progress of the whole class" (respondent 23). Other themes were teachers' skills and confidence in operating software (4 comments), measurement errors when students read refraction angles with a virtual protractor (3 comments), and infrastructure and lesson design time (3 comments). One teacher noted: "Not every teacher is proficient in complex technical operations in simulation software or knows how to handle unexpected software errors during a lesson" (respondent 25).

5. DISCUSSION

The first finding is that teachers used digital tools at the "Often" level, but student engagement was mainly passive: 64.0% of teachers reported that students mainly watched projected content and 10.0% described students in the constructive mode. According to the ICAP framework (Chi & Wylie, 2014), the same simulation can lead to different modes of engagement depending on the task the teacher sets. Digital tools are thus currently used mainly as visual aids, consistent with the 92.0% of teachers who identified visualising phenomena as the main way tools support students. The gap between the 72.0% of teachers who reported often organising students to predict and verify and the 10.0% who described students proposing their own predictions may arise because teachers interpret "organising" as the teacher running the simulation while students watch. It may also reflect social desirability in self-reported data (Podsakoff et al., 2003). The open-ended comments about students being distracted when operating devices suggest one reason why teachers choose to project simulations. This finding is close to the observation of Lê (2026) that using technology for learner management and assessment is a weaker part of teaching staff's digital skills.

The second finding is a gap between activities teachers consider valuable and activities they carry out. Although 78.0% of teachers regarded collecting and analysing experimental data as the activity that creates the clearest opportunities for digital competence, only 16.0% used data measurement, collection and processing tools when teaching Light, and data processing and analysis was among the functions with lower proportions of "Often" in Table 1. Within information and data exploitation, evaluating data reliability had the lowest mean (M = 3.58). Optics simulations such as PhET allow measurement of angles of incidence and refraction or of object and image distances (Wieman et al., 2008), and can therefore serve as a source of quantitative data for students to tabulate, graph and examine for error. The measurement error in reading refraction angles with a virtual protractor, mentioned in the open-ended comments, is a situation that could be used for students to evaluate data reliability, an indicator of the information and data exploitation area in the Digital Competence Framework (MOET, 2025).

The third finding is that the main difficulty in teaching Light lies in the quality of simulation use and in linking simulations, ray diagrams and real experiments, not in finding simulations. Lenses was the content the fewest teachers had taught, and investigating image formation through lenses had the lowest mean in Table 2. de Jong et al. (2013) argued that combining virtual and physical experiments needs deliberate design; Vietnamese studies have also proposed procedures for such combination (T. H. N. Võ et al., 2025) or for organising simulations within a learning cycle (Nguyễn, 2025). Regarding conditions, teachers identified first-order barriers (devices, 74.0%) more often than difficulties related to organising and assessing learning activities (Ertmer, 1999). Nevertheless, the needs for skills training (85.7%) and sample learning tasks (81.6%) exceeded the proportions of the corresponding difficulties. These needs relate to the instructional design and assessment areas of Natural Science teaching competence of lower secondary teachers (C. N. Võ et al., 2026).

Several implications follow. Teacher professional development could shift its focus from operating software to designing tasks in which students predict, investigate with simulations and explain with evidence. Sample learning tasks for the Light topic could require students to collect quantitative data from simulations and compare them with ray diagrams and real experiments, giving priority to lenses. Organisational arrangements need to take limited equipment into account, for instance student groups sharing a device with worksheets that specify operations and time limits, to reduce distraction.

6. CONCLUSION

This study surveyed 50 lower secondary school teachers on their use of digital tools in teaching the Light topic in Grade 9 Natural Science. Teachers used digital tools often, mainly interactive simulations, and held positive views of their role. However, students mainly participated at the level of observation; data processing, explanation and assessment functions were used less often than visualisation; and linking simulations with ray diagrams and real experiments was a difficulty reported by many teachers. Teachers expressed high needs for skills training and sample learning tasks.

The study has several limitations. The sample of 50 teachers was obtained through convenience sampling, so the results describe the participating teachers and are not representative of Natural Science teachers in general. The data are self-reported and were not compared with classroom observations; responses on the scales were concentrated at levels 3 and 4, which limits the discrimination between indicators. Only descriptive statistics were used. Further studies could combine classroom observation and interviews with teachers and students, test differences by teaching experience, and implement learning tasks that use simulations in the constructive mode when teaching Light.

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