



Teacher's Perceptions of Electronic Multi Representation STEM based Worksheet to Improve Student's Metacognitive Ability

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Abstract. Science teachers often conduct a teacher-centered learning process without analyzing the essential needs of each student. Yet, it may not support student to enhance their cognition ability in 21st century era. This study aimed to describe teachers' perception toward usage of electronic multi representation-STEM based worksheet. The study was conducted in February 2021, involving 245 student and 15 science teachers of junior high school. The research used a mixed method with Sequential Explanatory Design. Data were taken using Questionnaire, interview, and to analyze current student worksheet. Data were analyzed descriptively. The data analysis techniques are data collection, data reduction, data display, and verification. The result shows that student have a positive perception toward usage of the electronic multi representation-STEM based worksheet. Almost all the teachers did not use the STEM approach to teach science. The current worksheets has not completely train students' metacognitive abilities and the students' metacognition was in low category, teacher has not use proper learning strategies, method, and visualize concepts in multi representation. It can be concluded that a STEM-based multi-representation worksheet is needed to improve students' metacognitive abilities of junior high school.

Keywords: e-work sheet, metacognitive, multi representation

Introduction

Scientific experience is not enough to develop 21st century skills, but how to apply scientific concepts to design technological products and solve problems. Metacognitive as thinking about thinking which means thinking about one's own way of thinking. Metacognition was significantly positively correlated with control of learning beliefs, task value, and self-efficacy. Students with high control over their learning beliefs, high belief in their competencies to accomplish academic tasks, and who attached high importance to their studies, highly employed metacognitive learning strategies in their studies (Muwonge, et al., 2017).

Metacognition skills encourage student evolve into self-supporting learners who are responsible for their learning advancement (Sudjana & Wijayanti, 2018). Metacognition skills are needed in solving problems, developing creativity, and innovating (Herlanti, et al., 2017). Metacognition skills help learners become independent learners who are responsible for their learning progress (Oztruk, 2017).

Metacognition is the key to make learning more meaningful for the students in understanding the meaning of a concept and as a key component of academic success (Dang, et al., 2018). Metacognition can enhance conceptual understanding of science (Colthorpe, et al., 2018). But in fact, science learning in Indonesia has not maximally developed students' metacognitive skills. The learning paradigm focuses on cognitive aspects only and simultaneously uses a teacher-centered and non-constructivist pattern (Rahmat & Chanunan, 2018). Previous research has found that metacognitive skills and critical thinking skills have a positive correlation with process skills because the students' science process skills will be maximal if their metacognitive skills, as the control of the high order thinking, and the critical thinking skills are optimally developed, which is considered essential in order to encourage the students to be active in the learning activities (Naimnule, 2018).

The ability of educators to develop learning activities is one of the factors to improve students' conceptual understanding abilities (Susantini, et al., 2018). The strategy used to train metacognition skills is by applying the STEM approach. It is fit to improve students' cognitive capability, this is evidenced by research which clarify that there is impact on STEM integrated in problem-based learning practice by size effect value 0.74 categorized medium (Changtong, et al., 2020). STEM approach with PBL and PjBL models can be adapted as a method to enhance problem solving and scientific competencies through direct experiences (Liu, 2019; Linc, et al., 2019).

Learners are able to solve real-life problem related to environment and design using STEM strategy to make a waste management project (Tadenea & Salic-Hairulla, 2019). Other studies showed that challenging question enhance student STEM knowledge (Lai, 2018). STEM experience-based learning stimulate student to be active and enthusiastic in participating bio-product for environmental protection (Nguyen, et al., 2019). This statement is reinforced by the result of study that STEM integration project-based learning enhances student creativity and innovation as well as improve students' high level thinking (Keleman, et al., 2021). Research verifies high-order thinking skills (HOTS) is such an ability to apply skills, knowledge, and values in reasoning that can be used in the STEM field and may influence careers later (Lin, et al., 2018). The self-efficacy and learning motivation can also affect future career planning (Han, et al., 2021).

The selection of the right model also affects the learning process. There is a significant relationship between students' metacognitive abilities using the SiMaYang learning model based on multiple representations (Bela, et al., 2018). Through the multi-representation learning model, it is expected that students can find appropriate learning strategies by evaluating and correcting deficiencies in the learning process so as to improve their metacognitive abilities (Susantini, 2018). This is supported by the result of a study that revealed multi-representation explanation in virtual laboratory provide student understanding analytical chemistry practicum (Widarti, et al., 2021).

The representation help person to redefine a problem with his own words by connecting symbolic, graphical, verbal, and numerical representation (Alighiri, et al., 2018). Conceptual representation assist student in such area as making sense of complex phenomena, constructing representation in their mind and correcting prior understanding (Treagust, 2013). Based on Finnegan's (2019) observations, students were actively involved in sharing information they discovered from multimedia sources, websites, and trade books through multiple means (Universal Design for Learning-Representation). Furthermore, Lengkana (2018) explain that learning program with multi-based representation succeeded in developing students' representational abilities. Effectiveness of learning programs based on research data analysis on the aspect of representation, the relationship between the ability of representation with generic science skills, as well as mastery of concepts Anatomy and physiology of the human body.

The role of teacher in integrated STEM learning is helping student make abstraction and to decontextualize concept for application in a variety of different real-world, authentic context (Daher & Awawdeh, 2020). However, most teachers do not currently have the knowledge to bring STEM in the classroom. Teachers who did not value STEM education did not show higher readiness levels with more years of experience (Park, et al., 2017). Lack of control over pacing of curriculum and the sequence of instruction were also discussed as troublesome when teachers sought to integrate multiple disciplines for authentic STEM lessons (Herro & Quigley 2017).

Findings about the sufficiency and competency of teachers in providing learning support are worrisome. In relation to the more constructive-based approaches, teachers reported that they found it hard to help students use their self-generated representations to arrive at the canonical ideas (Waldrip & Prain, 2013). For instance, Anagün (2018) reported that teachers faced difficulties in performing authentic instruction that is also based upon a constructivist approach in classroom practices and thus that would normally require the management of a constructivist learning environment by the teachers. Also, teaching materials can contain practical activities and strategies that are introduced to students in practicing independent learning (Lara, et al., 2020).

Thus, through the use of appropriate strategies, models and teaching materials, students will be able to develop their metacognitive abilities. The aim of this study is to describe students' perceptions of the role of MR-STEM based worksheet to improve metacognitive abilities. The findings also provide a glimpse into the complexity of this pedagogical work, which can inform professional development of teachers to develop their teaching material preparation.

Methods

The participants of this research consisted of 245 students and 15 teachers in academic year of 2021/2022. Four science teachers and one curriculum person were chosen after giving a questionnaire to be interviewed with considering their written response. The study used mixed-method research adapted from Creswell. The research was conducted on 1 February-14 February 2021. First, the researcher conducted a literature study with an initial analysis examining the results of the latest research on the STEM approach, multi representation, use of teaching materials and metacognitive abilities. Next, the researchers developed an instrument for analyzing the needs of teachers and students in science learning, then the instrument was distributed to 10 schools via google form. After analyzing their questionnaire, a semi-structured interview for four science teachers and one curriculum person is conducted.

The research instruments are modified from Treagust (2013). There are three indicators of the questionnaire statement for student, namely: the STEM approach, the use of multiple representations, and the science learning process. The total questions on the STEM approach indicators are 4 items, the indicator for the use of multi-representation is 4 items, and the indicators for the science learning process are 2 items. The interviewed topic for teacher is related to given questions adapted from (Son & Lee, 2016). Some examples of the semi-structured interviews in this research include (1) What are the reason do you use worksheet in classroom?, (2) Why are you applied certain strategies to teach science concept?, (3) Why are you choose certain learning models?

To analyze data gathered in the study, data collection combines and analyze qualitatively and quantitatively. Figure 1 is a schematic research design in sequential research stages, starting with qualitative research and continuing with quantitative research that follow sequential explanatory design state (Shorten & Smith, 2017).

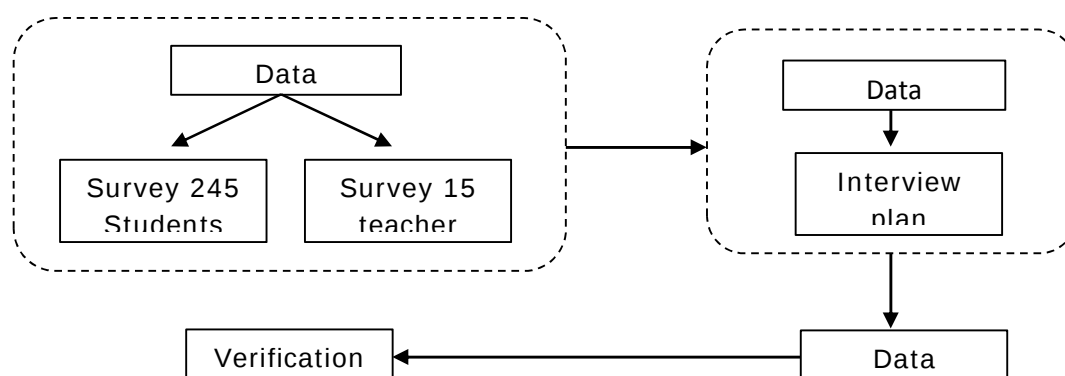


Figure 1. The schematic research design

There are data collection, data reduction, data display and verification. The primary data collected through questionnaire statement for student and semi-structured interviews by video call meeting with five teachers. The secondary data collected from literature review. The first part is analyzing the response from 245 students and 15 teachers. The data collected and then reduced and focused on important things related to research points. After the data is describe, it can be verified through completing interviews data and documentations. The procedures when conducting interviews include their response about learning process in their school. Further, the interview is done in order to find out the reason why they use worksheet in classroom, their strategies to teach science concept, the certain learning models.

The researcher organize data collected through questionnaire and calculated in percentage form response then analyze with SPSS 21 program to know the validity and the reliability of the instrument. Calculating the percentage of each item in the questionnaire using the formula and presenting the criteria adapted from Aini (2020).

Table 1. Interpretations of student's perceptions about E-worksheet MR-STEM based

Interval	Favorable	Unfavorable
$75 < x \leq 100$	Strongly Agree	Disagree
$50 < x \leq 75$	Agree	Less Agree
$25 < x \leq 50$	Less Agree	Agree
$0 < x \leq 25$	Disagree	Strongly Agree

Results and Discussion

The validity and reliability score are shown in Table 2. The result of the analysis showed correlation is significant at the 0.05 level. Cronbach's Alpha score for student's questionnaire 0,448 and score for teacher's questionnaire 0,956. According to Arikunto (2016) this result confirm that the instruments were valid and reliable.

Table 2. The result of instrument's validity

Student's questionnaire	Sig.	Teacher's questionnaire	Sig.
Q1	0,693	Q1	0,803
Q2	0,755	Q2	0,706
Q3	0,464	Q3	0,828
Q4	0,199	Q4	0,555
Q5	0,409	Q5	0,594
Q6	0,720	Q6	0,734
Q7	0,156	Q7	0,897
Q8	0,134	Q8	0,856
Q9	0,166	Q9	0,849
Q10	0,410	Q10	0,896
		Q11*	0,747
		Q12*	0,759
		Q13*	0,896

* Q11, Q12 & Q13: question for teacher about multi-representation and science learning process

The outcome of student perceptions towards electronic MR-STEM based worksheet can be seen in Table 3.

Table 3. Result of Questionnaire Students Perception towards electronic MR-STEM based worksheet (n= 245)

No	Statement	Percentage	Category
1	I find it difficult to understand science concepts because many verbal concepts	52	Agree
2	I find it difficult to work in the laboratory	48	Agree
Average number of Student's learning difficulties		50	Agree
3	I am interested in Electronic Student Worksheet which can be accessed anytime	60	Agree
4	I enjoy learning by use technology	51	Agree
5	I don't like doing project assignments in science class	56	Less Agree
6	I like science because the teacher gives examples from everyday life phenomena	53	Agree
Average number of Students liking science		55	Agree
7	I better understand the science concept while doing experiment	49	Less Agree
8	Science concept are easier to understand using animation, pict, video	52	Agree

9	Teachers deliver science concept use video and animation	42	Less Agree
10	Teachers use virtual lab on learning process	33	Less Agree
Average number of Laboratory facilities use		44	Less Agree

Student's Learning difficulties

The results revealed that students have strain in learning science, especially with verbal concept, so students prefer the concept presented by animation, drawings, pictures, and interesting video related to everyday life. Students prefer learning by doing science project or experiment in view of the fact that students are well known with factual illustration so students get enthusiasm in science lessons, but the lack of experience using laboratory tools make them difficult to work in a laboratory. The teacher rarely deliver concept with video and animation, however students find agreeable material related to digital media and would rather use it for the learning process.

The concept of science cannot be reached without being associated with several disciplines about various biochemical processes and understanding morphological changes, so that various levels of representation such as submicroscopic and symbolic are needed for biological phenomena (Destya, 2019). Ecosystems are essential materials because they focus on the basic characteristics of life. Students are taught how a species will relate to other species. This is the key to understanding many important things in the process of life. It also discusses the series of changes experienced during their life cycle, starting from the network level and even previous research by Putri & Rusyati (2020) showed that junior high school students experienced difficulties and misconceptions when working on tasks (manipulating graphs, graphic simulations) population changes in food webs. The concept of ecosystem is very broad, complex, and often presented unstructured. The content of the material contains the interconnectedness of knowledge at various levels, the invisible nature of which makes it a difficult subject to teach and learn.

Teachers' Preferred Approach in Science Learning

In today's technology era, it is possible to engage students more than traditional approaches. STEM (Science, Technology, Engineering, Math) approach can be adapted to enhance student's problem solving competencies in various situation. The following is an excerpt from the answer of several respondents.

Teacher 1 as curriculum person stated :

"I use STEM approach by choosing several concept that can be integrate with making a product. I train my students to be more active and doing task by discussing with the other students. The application of STEM approach can enhance student's creativity, students are also trained to create or modified a product as a solution for certain problem."

Teacher 2 stated :

"STEM approach is usually applied through project based learning or problem based learning. In group discussion, students trained through practical activities as result their hands-on ability enhance."

In summary, two respondents give the reasons STEM approach is suitable in science learning supported by trains students to be creative, create and modified a product, makes learning contextual and improve students curiosity in learning science.

In fact, other approach also applied in science learning, that is scientific approach. This was stated by three respondents.

Teacher 3 stated :

"I use scientific approach because it is easy to understand and most of 75% students motivate with my learning strategy."

Teacher 4 stated :

"Scientific approach commonly use in science learning, students train to do investigation, experiments, taking a deep look on daily live phenomenon in groups."

Teacher 5 stated :

"I often use scientific approach because it is effective to enhance students cognitive ability. Adjusted to the material, i train students' science process skills and scientific attitude."

The findings obtained that are teachers use scientific approach in delivering science concept to enhance students cognitive ability, discuss in group. The reason for using this approach is commonly use and easy to applicate. However, current learning has not yet achieved the general objectives of the curriculum by the reason of limited equipment and infrastructure, so that teachers are unable to integrate science and technology, and now and then the instrument cannot be represented to implement STEM. The limited learning source, strategy and methods may influence student's cognitive ability.

To overcome the problem, teacher must explore to find out what are the possible approaches and strategies that will work in a virtual classroom. Online learning is a totally different environment. In engaging students' participation, teachers say that technology and facilities support is important. This fact is reinforced by other research that even experienced users of technology do not necessarily have effective information literacy practices (Šorgo, et al., 2017). Students often lack confidence in their ability to use effectively use technology and engage with information, and may have unclear expectations of blended learning (Diep, et al., 2017).

Therefore, learning science can be fun if teaching science is carefully and creatively planned. Science teachers discovered that the use of STEM approach with project based, improve creativity and problemsolving student's ability (Liu, 2019). To encourage and facilitate constructivist learning, teachers must design, monitor, and review their learning in order to make the learning activities become student-centered. This is to ensure that teachers and lecturers provide meaningful learning experiences (Kabha, 2019).

The Implementation of Learning Models in Science

The learning model applied as a whole is following the curriculum suggested in the 2013 curriculum, but most frequently applied are discovery learning, inquiry learning, and problem based learning. Three science teachers said that the discovery learning model had been applied in science learning and the other use inquiry learning. The following is an excerpt from the answer of several respondents.

Teacher 1 as curriculum person stated :

"I once thought my students with a structured inquiry. I give task for laboratory activities or hands-on. Students train to collect, organize data and make a conclusion."

Teacher 2 stated :

“Discovery learning ask students to investigate problem given by teacher through defined procedures.”

Teacher 3 stated :

“I use discovery learning model because it is easy to applied on junior high school students. I called it structured inquiry, the question and procedure given by the teacher then student construct explanation provided by real proof .”

Teacher 4 stated :

“Inquiry model train students to observe, be critical, search and use relevant information to understand phenomenon through experiment, using tool to collect data, analyze, and interpret data.”

Teacher 5 stated :

“In class, we implemented inquiry learning model because we want students involved in real investigation. It helps them identify conceptual problem and give task to overcome the problem.”

Based on this information, the inquiry learning model has been applied in schools in learning. Inquiry is a procedures used by students to decide a doubt (Singh & Kaushik, 2020). In order for students to develop long-term understanding of science ideas, they need to be presented with science information in both linguistic and visual (non-linguistic) modes, as well as be required to coordinate the ideas from both types of modes (Mayer, 2014).

Some students find it easier to understand science with multiple representation (pictures, gesture, sketch, table, graph, animation, video). A wide variety of representations have been used by science teachers. Researchers have found an increased of student learning scientific concepts. Students had adopted the more modes and used them more consciously without using unnecessary modes (Oz, et al., 2018). Students reasoned before, through, and from drawing, and in the astronomy case constructed a collaborative drawing that enabled participant students to check their understanding as they core presented claims. These findings extend the current broad case for learning opportunities arising from student drawing. This mode can make a distinctive and valuable contribution among other modes to science learning (Tytler, 2020).

In fact, a study revealed that applying multi representation learning based influence student's metacognitive ability (Ita, et al., 2021). This supported by similar research reveal that physics learning tools based on hypermedia can improve problem solving skills of students in the aspect of problem solving, mathematical skill, space and graphs awareness, as well as estimation-approximation (Amin, et al., 2019). Utilization of hypermedia that displays various forms of representation such as text, diagrams, formulas, structural models, animation, and video promote student comprehending complex science topics (Azevedo, 2005).

Electronic Worksheet in e-Learning

Some science teachers decided to update their technology-based instructional materials by making it more interactive. Electronic based instructional material requires in increasing students' learning interest (Anwar, et al., 2019). Electronic worksheet facilitated student communicating with teachers due to online learning (Sumarni, et al., 2021). Further research found that the augmented reality (AR) worksheets improved

learning outcomes more effectively than paper worksheets and also performed better interaction among learner, mobile device, and physical context (Zhang, 2020). E-Worksheet is considered appropriate to online class and more effective so that students can be read up on from home (Syafitri & Tressyalina, 2020). Based on the answer to the five respondents, electronic worksheet considered suitable to improve student's metacognitive skills. The findings of the survey were obtained as follows.

Teacher 1 as curriculum person stated :

"Students are motivated by the use of electronic worksheet because of interest in technology, color digital displays and supporting animations are relevant to the concept so that students *feel enthusiastic* for learning."

Teacher 2 stated :

"It helps a lot during the limited face-to-face meetings, I send the electronic worksheet via Whatsapp and students can do their exercise everywhere and anywhere."

Teacher 3 stated :

"Electronic worksheet has presented the concept in various forms of representation. For example, there is a delivery discourse accompanied by pictures of bananas, cassava, shallots, water guava, flowers roses, aloe vera then students are asked to group the plant according to the way of reproduction and asked to Mention 5 examples of other plants from around the place where they live."

Teacher 4 stated :

"I use this teaching material because with digital platform i can make interactive task for students. Students can see the feedback given automatically after completing their task."

Teacher 5 stated :

"Electronic worksheet need developmet and customization so that provided investigation activities with the integration of several disciplines. This is due to limitations learning time and concepts only focus on integrated science, and not yet have applied the science of engineering, technology and mathematics."

In summary, five respondents give the reasons that electronic worksheet suitable to improve students metacognitive skills supported by time and materials efficiency, easy to access, provide students motivation, and intresting to learn. Learning media must be attractive and easy to understand by students, as is the case with electronic worksheet, because it contains detailed investigation activities. Leads to the real application of abstract concepts (Fitriani, et al., 2017). Learners are trained to find concepts independently both in discussions group and individual assignments (Annafi, 2016). Students will complete a series of tasks with the aim of solving a problem and make independent conclusions (Iryani, et al., 2016).

Electronic worksheet is required for optimization of teaching and learning activities (Yasa, et al., 2018). Electronic worksheet as student learning material is arranged digitally and developed systematically continuously at a certain time as needed (Rai, et al., 2021). Questions and activities in electronic worksheet also affect the enthusiasm of participants educate. Electronic worksheet based on HOTS (high order thinking skills) will support the ability of students to analyze and interpret concepts already owned. Not only remembering but students can apply concepts in problem solving in everyday life (Hartik, et al., 2021).

Teachers must have good classroom management skills during online learning, the use of electronic worksheet is very effective and can be the solution to improve understanding of concepts in face-to-face learning limited (Choo, et al., 2011). Electronic worksheet is easy to access anytime using a computer, laptop or cell phone, the price is more affordable and friendly environment (Kharisma, et al., 2021). The electronic worksheet features with video, audio, and animations make learning adaptive, innovative and not boring (Rohma & Puspitawati, 2021). Electronic worksheet is more attractive to use during online learning and can train students' critical thinking processes (Haryanto, et al., 2020). Learning using electronic worksheet can increase the sensitivity of students to current environmental problems so that they are able to realize an action to overcome environmental problems and be more open to technological views, in other words scientific literacy will increase (Rochim, et al., 2022).

Improving Student's metacognitive ability

Various learning strategies, models, teaching materials have been applied by teachers. Yet metacognitive indicator have not been maximally developed. The obstacles are expressed in the answer of the respondents as follow:

Teacher 1 as curriculum person stated :

"I feel the time allocation is not enough to convey all the science subject matter being taught. I have to observe the students learning need during the limited face-to-face meeting. The worksheet i use have not display specified model so that research and observation activities not shown in detail and only in the form of a collection of practice essay questions."

Teacher 2 stated :

"When preparing the material, the assignment was also one of the obstacle i experienced. As example, the electronic worksheet had not been able to train students in representing the material concepts of plant and animal breeding systems in various forms. The reason is because difficulty understanding material, such as in changing the explanation of process concepts moss life into a cycle diagram and vice versa. Some students have not accustomed to organizing data in the form of tables and graphs."

Teacher 3 stated :

"Electronic worksheet had not provided investigation activities with the integration of several disciplines."

Teacher 4 stated :

"The obstacle are limited references, time, material, and facilities."

Teacher 5 stated :

"The existing constraints due to limitations learning time and concepts only focus on integrated science, and not yet have applied the science of engineering, technology and mathematics."

Based on the above findings, it is in line with the research conducted by Kartini, et al. (2022) which explain that teachers have obstacle in choosing appropriate learning techniques and models for students. In addition teachers are still not optimal in managing time. Teachers need sufficient time to organize their students to do activities and provide group guidance. In addition to overcome the obstacle so that student's metacognitive ability improve, efforts have been made.

Teacher 1 as curriculum person stated:

“Selection of appropriate models, approaches and teaching materials will help participants students develop their metacognitive abilities. The multi-representation learning model is a learning model which is believed to help train students' metacognitive abilities. The approach used to improve participants' metacognitive abilities learning is with a STEM approach. Students are involved in defining and formulating a solution to authentic problems in everyday life. The concept of science helps students understand natural phenomena, the use of technology as a supporter of the design, engineering is used to apply scientific findings with appropriate tools and mathematical formulas as the basis for analytical calculations.”

Metacognition indicators can be known when students carry out learning activities with the STEM approach. The scientific aspect can be the initial stimulus for students to make plans and goals to solve problems (Planning). Aspects of technology and mathematics can appear in the activities of students choosing and determining the right strategy and processing relevant information (Predictive skills). The engineering aspect arises when students assess and evaluate problem-solving strategies and perform to achieve learning objectives (Kustiana et al., 2020).

The developed electronic worksheet consists of steps of investigation and observation using various modes of representation (diagram, cycle, video, animation, verbal). The influence of the use of the learning media on argumentative representation competence increase the learners' conceptual understanding. It made an impact in their argumentative representation competence which then helped them to understand more content (Liliarti, 2018).

Conclusion

Based on teachers' interviews about teaching material to improve metacognitive ability in secondary school, it is necessary to provide a teaching material that generate possibility for students to expertise and master science. Electronic Multi representation-STEM based worksheet can improve students metacognitive ability.

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