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Design and validation of learning sequences of PGSD Sanata Dharma University student to teach the fraction concept for primary student using Montessori manipulatives

Aprinastuti C. ; Amelia M.A.
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[a] Primary Teacher Training Education Department, Faculty of Education, Sanata Dharma University, Yogyakarta, Indonesia

Abstract

Fraction concept is one of the learning problems that often occurs in elementary students. Elementary student 's misconceptions can be caused by teacher's misconceptions. PGSD students are teacher candidates, so they must have the correct concept then they can teach the concept of fractions correctly too. Learning must be an inspiration for students when they become teachers later. One medium that can be used to teach fraction concepts is media based on Montessori . Local culture can support the use of Montessori media. This study aims to design and validate the learning sequence of PGSD Students in using Montessori media, to develop design principles to teach fraction concepts in elementary school students. The approach in this research is design research which includes three phases, namely design , trial and assessment. In the design phase, researchers formulate students' prior knowledge and learning objectives. This is used as the basis for the sequence of learning . This stage of learning is evaluated in a repeat trial phases, the hypothesis design principle is developed and from which the learning stages are redesigned. The results of the assessment phase, together with the experience of the previous cycle and research review, are used to perfect the design principles of the student 's learning sequences so they can teach the concept of fractions correctly.

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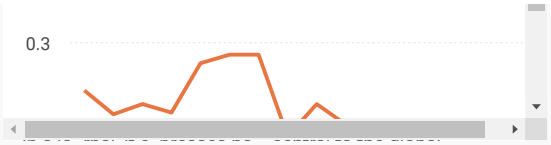

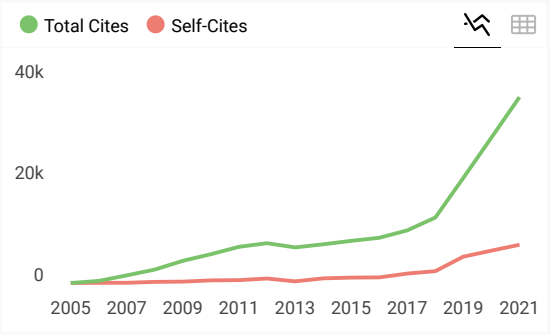

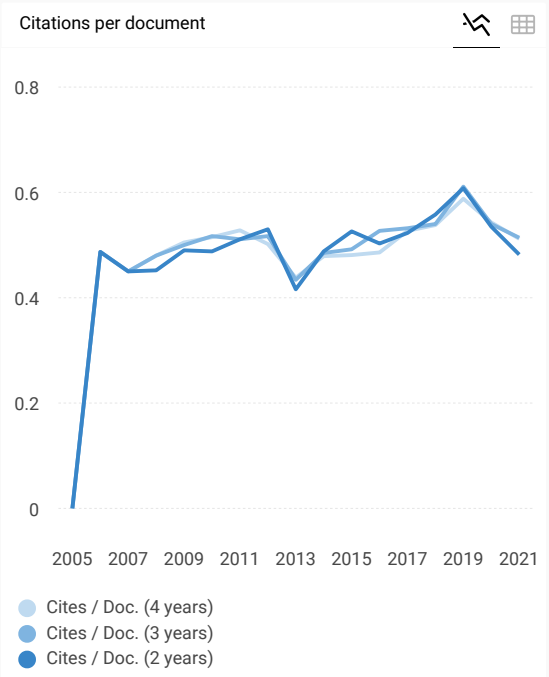

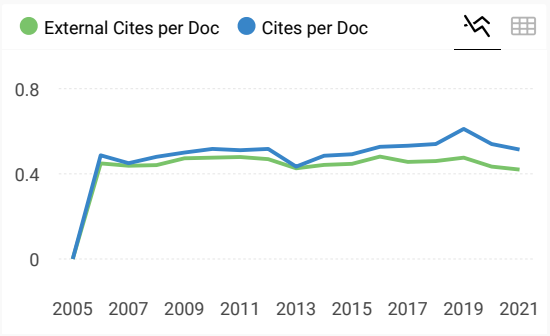

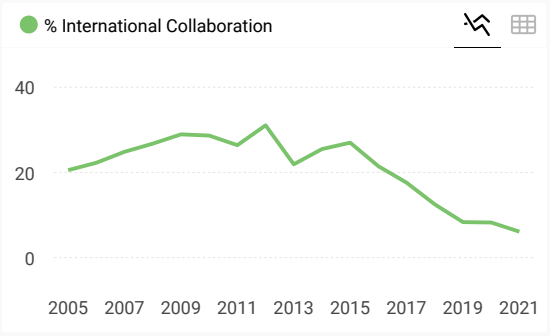

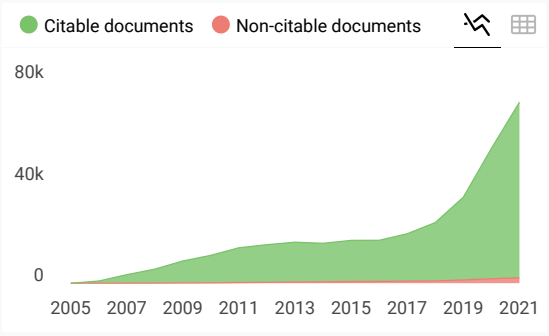

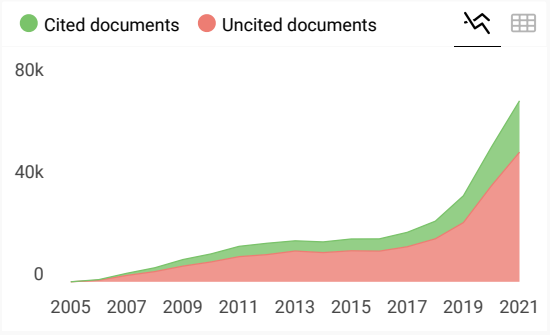

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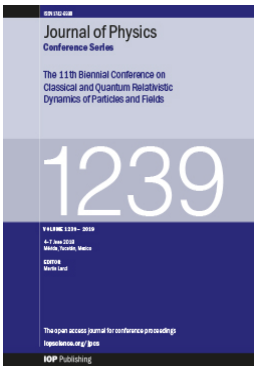

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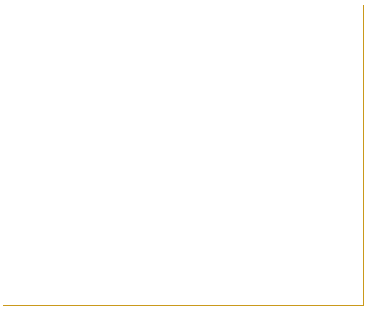

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The 7th South East Asia Design Research International Conference (SEADRIC 2019)

Yosep Dwi Kristanto

Chair of the SEADRIC 2019, Faculty of Teacher Training and Education, Universitas Sanata Dharma, Mrican, Tromol Pos 29, Yogyakarta 55002, Indonesia

E-mail: yosepdwikristanto@usd.ac.id

Faculty of Teacher Training and Education, Universitas Sanata Dharma, has become the host of the 7th South East Asia Design Research International Conference (SEADRIC 2019) from 25 to 27 July 2019. The conference has served as a forum to bring together researchers from the field of education in studying learning from the design research perspective. The forum emerged in the early 2010s with the first three SEADRIC held in 2013, 2014, and 2015 at Universitas Sriwijaya, Palembang. Subsequent SEADRIC events were held at Universitas Negeri Padang (2016), Universitas Lambung Mangkurat, Banjarmasin (2017) and Universitas Syiah Kuala, Banda Aceh (2018). The SEADRIC 2019 has the first SEADRIC which was supported by the Ministry of Research, Technology, and Higher Education of the Republic of Indonesia.

In bringing SEADRIC 2019 into reality, we have envisioned four core values; rigor, impact, prestige, and service, as the building bricks of the foundation of our effort and hard work. We have accomplished these core values through different aspects of the conference.

In terms of *rigor*, we have ensured that all submitted abstracts have undergone double-blind peer review and had clear criteria for abstract acceptance. These criteria filtered two hundred and thirty unique abstracts into two hundred and twenty-one, whose full paper were further selected by 41 outstanding reviewers from different institutions. This thorough selection process has made this conference the best venue to discuss various topics in education, among others are design research, PMRI, problem-based learning, ethnomathematics and problem-solving.

We have strived for *impact* by collaborating with many high-quality national and international journals, ensuring impactful studies to be included in the conference by funding selected participants to accommodate the geographic diversity of our authors. The journals partnering with us are Journal of Physics: Conference Series, Jurnal Pendidikan IPA Indonesia, Journal on Mathematics Education (JME), Jurnal Pendidikan Matematika, REiD (Research and Evaluation in Education), Infinity Journal, International Journal on Emerging Mathematics Education (IJEME) and LLT Journal: A Journal on Language and Language Teaching, which evidently belong to diverse fields and in turn, wider readership. Furthermore, the impact of our conference has also been ensured through the spread of our authors, who do not only come from different parts of Indonesia, but also from other countries.

We have strived for *prestige* by inviting distinguished speakers who are experts in their fields and have obtained an acknowledgement from the Ministry of Research, Technology, and Higher Education of the Republic of Indonesia. We have five keynote speakers from five different countries, i.e. Prof. Toh Tin Lam (National Institute of Education, Singapore), Dr. Wanty Widjaja (Deakin University, Australia), Dr. Maarten Ludovicus Antonius Marie Dolk (Utrecht University, Netherlands), Dr.

Hongki Julie, M.Si. (Universitas Sanata Dharma, Yogyakarta, Indonesia), and Prof. Dr. Masami Isoda (University of Tsukuba, Japan). Furthermore, we have nine invited speakers along with three workshop instructors. The presentations of those speakers can be accessed from the conference website (https://usd.ac.id/seadr).

In terms of for *service*, we have delivered our best through the committee who have taken the participants' best interests at heart; facilitated all the participants throughout the conference; as well as appreciated and recognized outstanding papers by giving the best paper and best student paper awards. Congratulations to the following papers that have won SEADRIC 2019 best paper and best student paper awards, respectively.

1. Reflective Thinking Skills of Engineering Students in Learning Statistics by R. A. Funny (published at J. Math. Educ. **10** 445–458).
2. The Learning Trajectory of Pattern Number Learning Using Uno Stacko Game by I. Risdiyanti and R. C. I. Prahmana (published at J. Math. Educ. **11** 157–166).

The conference theme of SEADRIC 2019 was "Improving Professionalism and Reflective Thinking through Design Research." It has invited us to reflect on the current educational challenges, e.g. globalization and industrial revolution 4.0 and transform them into opportunities through design research. It has acknowledged the need to develop our professionalism so that we can proactively contribute to the advancement of educational science and praxis. It has challenged us to re-think the design research as a method to make learning and teaching innovation possible, but also as a paradigm in building our capacity for innovation.

In this proceedings, you will find a wide variety of perspectives and research findings with regard to educational design research and other topics in the field of education, and we hope that you will have insightful and fruitful conversations during and after the conference.

Finally, we want to thank Sanata Dharma University; Ministry of Research, Technology, and Higher Education of the Republic of Indonesia; Sogang University and SEAMEO QITEP in Mathematics for their contribution to fund the SEADRIC 2019. We also express our deepest gratitude to the many people who have made the conference possible, i.e. the organizing committee, the steering committee, reviewers, student volunteers, and all conference presenters and participants. Your contributions make educational design research a thriving and sustainable field.

Message from Sanata Dharma University Rector

On behalf of Sanata Dharma University, I feel honored to welcome all speakers and participants of the 7th South East Asia Design Research International Conference (SEADRIC 2019). I also would like to extend my warmest regards to all of you. Let us first thank the Almighty God for the grace we have received in attending this conference. I do hope this conference functions as an effective way to strengthen our role and improve our knowledge contribution as lecturers and researchers. I also wish that the 7th SEA-DR 2019 facilitates a fruitful sharing and exchange of ideas related to the conference's theme on "Improving Professionalism and Reflective Thinking through Design Research."

As a Jesuit University, Sanata Dharma is fully aware of the complexity and dynamics of learning because it is highly connected with identity, culture, and its less structured outcome that is difficult to measure. Moreover, learning in general is not merely about technical endeavor but more mental and spiritual one. The success of learning is much affected by the quality of enthusiasm, curiosity, self-esteem, and mode of dialog enjoyed by both students and lectures. Through such understanding, Sanata Dharma University commits to embrace and implement authentic and contextual learning by adopting unique learning paradigm called Ignatian Pedagogy. Employing Ignatian Pedagogy, learning outcome is directed to fully recognize that students are unique but expected to be a whole person having high *competence* in their field of study, capable of having *conscience* in their feeling and mind, and commit to develop their *compassion* to others. It is 3C in short.

To achieve such learning outcomes, Ignatian pedagogy needs a unique learning dynamic. It should provide enough time, space and attention to facilitate students' multi-sensory experiences from head, heart, and hand. Only through such dynamic, learning would be personalized, authentic, and far from being formalistic. In practice, Ignatian pedagogy requires learning activity that follows a 5 steps cycle: start from understanding context, intensively using and recognizing real past experiences, doing some real related actions, employing comprehensive evaluation, and facilitating in depth reflection. Therefore, I position this conference as a highly relevant response to the recent call to all of us in improving our leaning quality while we are witnessing the rapid change of modern learning that is much influenced by sophisticated smart technology.

I do hope that the conference becomes a good avenue not only to discuss our research findings but also to facilitate a fruitful dialogue in which sharing of knowledge, values and awareness that take place with joy and respect to each other. It is through such an orientation that we can proactively contribute to shape up our new generation for the betterment of our society. May the conference be successful and enjoyable. Thank you.

Johanes Eka Priyatma, PhD
Rector of Sanata Dharma University

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Design and validation of learning sequences of PGSD Sanata Dharma University student to teach the fraction concept for primary student using Montessori manipulatives

C Aprinastuti and M A Amelia

Primary Teacher Training Education Department, Faculty of Education, Sanata Dharma University, Yogyakarta, Indonesia.

E-mail: christiyantia@usd.ac.id, amelia@usd.ac.id

Abstract. Fraction concept is one of the learning problems that often occurs in elementary students. Elementary student's misconceptions can be caused by teacher's misconceptions. PGSD students are teacher candidates, so they must have the correct concept then they can teach the concept of fractions correctly too. Learning must be an inspiration for students when they become teachers later. One medium that can be used to teach fraction concepts is media based on Montessori. Local culture can support the use of Montessori media. This study aims to design and validate the learning sequence of PGSD Students in using Montessori media, to develop design principles to teach fraction concepts in elementary school students. The approach in this research is design research which includes three phases, namely design, trial and assessment. In the design phase, researchers formulate students' prior knowledge and learning objectives. This is used as the basis for the sequence of learning. This stage of learning is evaluated in a repeat trial phases, the hypothesis design principle is developed and from which the learning stages are redesigned. The results of the assessment phase, together with the experience of the previous cycle and research review, are used to perfect the design principles of the student's learning sequences so they can teach the concept of fractions correctly.

1. Introduction

One basic subject taught in primary education is mathematics. Mathematics, according to Ghani & Maat, (2018; 11) need a unambiguous concept comprehension, because it is a "calculation process". Mathematics concept comprehension is a continual process of learning. It need proficiency of "basic mathematical concepts" from prior knowledge concepts (Sarwadi & Shahril, 2014). Mathematics is considered important because it is the basis for understanding other knowledge and the basis for solving everyday problems.

Fraction is one concept of mathematics that student have to perceive. Unfortunately, this subject is considered difficult for students to understand. It is also mentioned by Aghazo & Alghazo (in Ghani & Maat; 2018; 112), one concepts in mathematics that is not easy for students is the faction. To perceive the fractions concept, students have to comprehend "fractional nature". Students normally construct "the fractional knowledge" from their "existing knowledge". If their current knowledge is contaminated with conceptual misunderstandings, it will affect their future learning related to the concept. The concept of fractions in mathematics is always considered difficult by students because they assume that numerators and denominators are integers that need to be shared with each other. The difficulties experienced by

students are due to the fraction material, students cannot understand it concretely, even misconceptions often occur. There are two kind of knowledge in Mathematics learning, Conceptual knowledge and conceptual understanding. Conceptual knowledge is the ability to see interconnections among ideas and procedural knowledge, understanding processes and algorithms to produce results (Hallett, Nunes, & Bryant, in Bentley & Bosse, 2018; 234). According to Van Steenbrugge (in Bentley & Bosse, 2018; 234). If conceptual knowledge that students' have on fractions is limited than their procedural knowledge or they are not understood the fraction procedure conceptually, they may only develop essential comprehension of fractions.

This misunderstanding will lead to errors that lead to misconceptions. This statement is in line with Mohyuddin & Khalil's statement (in Ghani & Maat, 2018; 112). Kawulich et al., (In Ghani & Maat, 2018; 112) defines misconceptions as "The understanding that is against the true meaning". Whereas Ojose (in Ghani & Maat, 2018; 112), stated that misconceptions occur due to misunderstanding and misinterpretation of knowledge from inaccurate meanings. Ojose mentioned that a misconception occurs from the change of meaning by pupils to suit the instructions given. Azurah Mohd Johar et al., (In Ghani & Maat, 2018; 112), concluded that pupils often use the same rules, subtraction, multiplication and division with the same procedures without considering the concept of association. These problems have to be determined by the correct concept for solving fraction problems. This is one of the challenges for teachers in teaching fraction material so that students easily understand it and avoid misconceptions.

According to Ghani & Maat, (2018; 112) Teachers must assure that their students have perceive “fractional knowledge” from the primary education. As prospective teachers, Primary School Teacher Education (PGSD) students need to be prepared to face challenges regarding teaching fractions to elementary students. PGSD students need to master the concept of material first, then they need to master how to teach the material to primary school students. One factor that can affect Student comprehension on mathematics is effectiveness from teacher (Stepek et al., in Queensland Government, Queensland studies authority, 2013: 4). Many studies reveal that effective teaching requires teachers to understand mathematical concepts, as well as how students interpret problems and build knowledge (Stepek et al. 1997).

Teachers may be able to raise the level of proficiency selected students by revisiting concepts that need further attention. The approach should be informed by existing knowledge students and their ability to integrate new information to develop conceptual understanding. The literature strongly advocates that teachers use a student-centered approach to teaching, especially when introducing new concepts. The Queensland Government, Queensland studies authority (2013, 5) reports that it is in the literature that mastery of fundamental concepts is necessary for the development of, and success in, higher-order skills, and that teachers play an important role in facilitating this development. Observations from many researchers suggest a stronger competency in foundation concepts before students move to performing complicated operations in an area that is widely considered complex.

To teach fraction material to elementary students, it will be easy if the teacher / teacher candidates use learning manipulatives. Learning manipulatives useful for teach something abstract to be more concrete for elementary students. Manipulatives are defined as manipulatives as concrete materials (eg, blocks, tiles) that are used to support the execution of a mathematical procedure (Laski, Jor'dan, Daoust, and Murray, in Vang, 2017; 3)." Uribe-Flórez, and Wilkins (in Vang, 2017; 3), described math manipulatives as "objects that can be touched, moved about, and rearranged, or stacked." According to Johnson (in Vang, 2017; 3), sudents use the concrete objects in hands-on experiences that help build connections between the manipulatives and the concept. Students enjoy using manipulatives to help them understand mathematical concepts. Using manipulatives helps them gain more in depth knowledge about key math concepts. Teachers must begin with clear, concrete demonstrations that explain the relationship between the manipulatives and the mathematical concept, and then, move on to more abstract demonstrations (Vang, 2017; 6).

Boggan et al (in Vang, 2017; 9), said that the benefit for student if the teachers use manipulatives in classrooms, are: (1) use their “previous understanding”, (2) students can relate with their “thinking”, (3), “understand” what they are working with, and finally (4) make “connections” with the mathematical

concepts of being taught. In conclusion, if teachers using manipulatives in the classroom, they help students understand key mathematics concepts, gain mathematical knowledge, abstractly, and increase test scores.

One of the courses offered to PGSD students is the International curriculum: Montessori Method. The Montessori Method has specificities related to the use of learning manipulatives for students. Based on this background, researchers want to conduct further research on how to teach fractions using Montessori media for PGSD students.

2. Methodology

The research conducted is research design research. According to Plomp (in Plomp & Nieveen, 2010; 13), design research is a systematic study of educational interventions designing, developing and evaluating (such as programs, teaching-learning strategies and materials, products and systems) as solutions for complex problems in educational practice, which also aims at advancing our knowledge about the interventions and processes of designing and developing them.

The research subjects were selected from senior students who already had experience in how to interact and teach elementary students. From all PGSD students selected 39 students that already have experience how to interact and teach elementary students (semester 6) and attend Curriculum courses based on the Montessori Method 2 (6-12 years). The course is a concentration course in PGSD study program.

In this research design the researcher wants to design the best steps in teaching students about the use of fraction Montessori media so that students can teach elementary students with the right process and results.

Plomp (in Plomp & Nieveen, 2010; 15) Authors may vary in how they picture design research, but they all agree that design research comprises of a number of stages or phases:

a. Preliminary research: needs and context analysis, review of literature, development of a conceptual or theoretical framework for the study
b. Prototyping phase: iterative design phase 3 consists of iterations, each being a micro cycle of research with formative evaluation and improving the refining the intervention
c. Assessment phase: (semi-) summative evaluation to include whether the solution or intervention meets the pre-determined specifications. As also this phase often results in improvement of intervention, we call this phase semi summative.

3. Result and Discussion

3.1. Design and validation of teaching-learning sequences

The theoretical framework of ‘design and validation of teaching-learning sequences’ comprises some general theoretical considerations regarding students’ learning. Firstly, the framework is based on a constructivist view of the learner. Secondly, the teacher is considered to be the holder of the scientific knowledge with common alternative ideas of the teaching content. The teacher’s introduction of concepts and systematic planning of situations for the use of concepts is crucial. Thirdly, students should be given opportunities to conceptualize the fraction content by means of talking and writing. Moreover, the framework emphasizes formative evaluation of students´ progress and from this the teaching-learning sequences (TLSs) should be developed consciously and systematically (Wallin and West, 2013: 179).

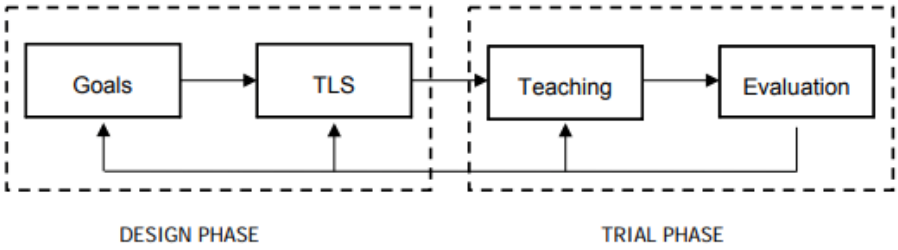


Figure 1: The iterative, cyclic process of design and trial phases (Andersson & Bach, 2004, p. 3)

3.2. Design Phase

Preliminary research

Initial research is done by determining the learning objectives: students are able to understand the use of Montessori media and teach using the media with the right process for elementary students. After the learning objectives are determined, the selection of Montessori media that will be taught to students will be conducted according to the learning objectives. For this study two Montessori media were selected.

a. Fraction circle

b. Cut-out labeled fraction circles

Prototyping phase

Learning activities designed for this research are:

a. fraction similarity
b. addition of fractions with the same denominator
c. addition of fractions with different denominators
d. subtraction of fractions with the same denominator
e. subtraction of fractions with different denominators

From these learning activities 3 iterations will be made, which are divided as follows:

1) Iteration 1: the similarity of fractions
2) Iteration 2: addition of fractions with the same and different denominators
3) Iteration 3: substraction of fractions with the same and different denominators

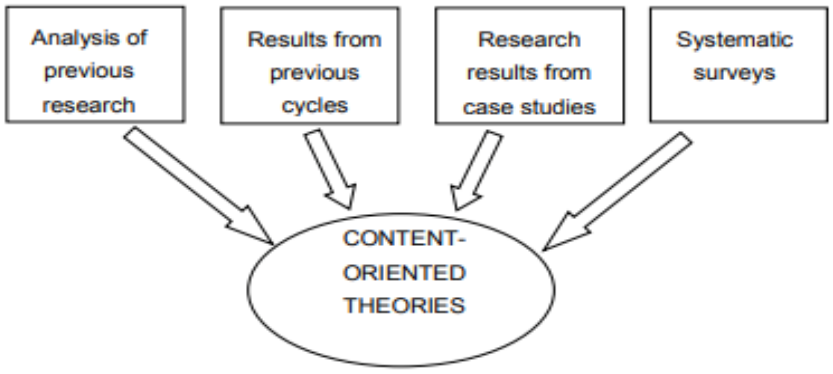
In each iteration, the following steps are taken:

a. Lecturers introduce Montessori media to be used. Broadly speaking, the lecturer mentions the use of the media and the steps to use the media.
b. Students act as elementary students and lecturers act as teachers so students understand how students need. Students are asked to do some questions about fractions using Montessori media.
c. Students try to teach material to other students. Students ask friends who are students to work on the questions and assess the work process and the friend's answers.
d. Lecturers provide reinforcement-reinforcement or suggestions of what students have done.
e. After one stage is complete, repeat from step 1, with different material.

Assessment phase

At the assessment phase, students were asked to make a summary in the form of a Montessori album to show their understanding.

Yield of the project: Content-oriented theories



According to the framework of ‘design and validation of teaching-learning sequences’ content-oriented theories are composed of three different categories of design principles:

• content-specific design principles,
• design principles concerning the nature of science, and
• general design principles.

4. Conclusion

The conclusions of this research are in the design phase, researchers formulate students' prior knowledge and learning objectives. This is used as the basis for the sequence of learning. This stage of learning is evaluated in a repeat trial phases, the hypothesis design principle is developed and from which the learning stages are redesigned. The results of the assessment phase, together with the experience of the previous cycle and research review, are used to perfect the design principles of the student's learning sequences so they can teach the concept of fractions correctly.

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