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Reconstruction of laboratory activity design "menyelidiki makanan berkarbohidrat" on digestive system material

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Abstract

Laboratory activities are essential in improving the understanding of learning outcomes and supporting the process of forming students' knowledge about biological material, especially the concept of carbohydrate digestion. It is necessary to laboratory activities design (LAD) that can support forming student knowledge in laboratory activities to investigate carbohydrate foods. This research uses a qualitative descriptive method applied through ANCOR (Analyse, Try, Reconstruct) steps to develop LAD that supports students' knowledge formation process. The ANCOR stages include analysing the sample LAD, conducting trials, and reconstructing it into a new LAD per the Ministry of Education and Culture's learning outcomes. The LAD reconstruction aims to strengthen students' understanding of carbohydrate digestion through laboratory activities emphasizing exploration, direct observation, and active involvement of students in the learning process. It is expected that the use of LAD that has been adjusted will make a significant contribution to improving student learning outcomes in biology materials, improving the learning process in the laboratory, and increasing their understanding of the concept of organ structure and function in the carbohydrate digestive system.

Abstrak. *Kegiatan laboratorium memegang peranan penting dalam meningkatkan pemahaman, hasil belajar, dan mendukung proses pembentukan pengetahuan siswa. siswa tentang materi biologi, khususnya konsep pencernaan karbohidrat. Perlu Desain Kegiatan Laboratorium (DKL) yang dapat mendukung proses pembentukan pengetahuan siswa pada kegiatan labororatorium menyelidiki makanan berkarbohidrat. Penelitian ini menggunakan metode deskriptif kualitatif yang diterapkan melalui langkah-langkah ANCOR (Analisis, Coba, Rekonstruksi) untuk mengembangkan DKL yang mendukung proses pembentukan pengetahuan siswa. Tahapan ANCOR tersebut meliputi analisis DKL sampel, melakukan uji coba, dan merekonstruksi menjadi DKL yang baru yang sesuai dengan capaian pembelajaran Kemendikbud. Rekonstruksi DKL bertujuan untuk memperkuat pemahaman siswa terhadap konsep pencernaan karbohidrat melalui kegiatan laboratorium yang menekankan eksplorasi, pengamatan langsung, dan keterlibatan aktif siswa dalam proses pembelajaran. Diharapkan penggunaan DKL yang telah disesuaikan akan memberikan kontribusi yang signifikan dalam meningkatkan hasil belajar siswa dalam materi biologi, memperbaiki proses pembelajaran di laboratorium, serta meningkatkan pemahaman mereka tentang konsep struktur organ dan fungsinya pada sistem pencernaan karbohidrat*.

A. Introduction

The constructivist approach to biology learning links direct experience and reflection in building students' knowledge (Nuryati & Fauziati, 2021; Anastasha & Movitaria, 2020). One of the essential concepts in biology lessons is the relationship between organ structure, organ systems and their functions in the digestive system (Cuarón et al., 2014). This concept includes the process of digestion and absorption of food substances, including carbohydrates (Putra & Wulandari, 2021), which are related to nutrition and health (Sensoy, 2021). Although the material of the digestive system and absorption of substances has been widely studied and understood, innovative and effective teaching methods to build students' understanding of this topic are still challenging. The method used so far is still monotonous, namely the lecture method, with low biology learning outcomes obtained (Rajagukguk, 2019). One method that can be applied is the practicum method in the laboratory.

As previous studies have shown, laboratory activities can improve student understanding and learning outcomes (Sormin, 2023; Nisa, 2017). However, several challenges need to be overcome in designing laboratory activities to study the absorption system of substances in the human body. It is necessary to design appropriate activities to accurately reflect food digestion and absorption processes (Lathifah et al., 2022). This involves selecting appropriate materials and methods to create realistic situations in the laboratory. Then, it is essential to integrate science principles with the context of daily life in laboratory activities. Thus, students can see the relevance and application of science concepts in their daily lives (Astuti et al., 2018), including the role of carbohydrate digestion in understanding the role of organ structure and function.

Through the use of food models or ingredients, students can observe how digestive enzymes such as amylase work to break down carbohydrates into simpler forms (Sensoy, 2021). In addition, by looking at the microscopic structure of the organs involved in absorption, such as the villi and microvilli in the small intestine, students can understand how increased absorption surface area allows for more efficient nutrient absorption (Sugito et al., 2007).

After experimenting, students will be encouraged to reflect on their experience and discuss the relationship between organ structure and organ system function in carbohydrate digestion. This can allow students to build their knowledge of biology and help them connect theoretical concepts with their practical experiences in the laboratory (Malik et al., 2019; Rabiudin, 2023). However, the LAD that exists so far is still a design of laboratory activities designed as verification or proof of a concept (Hindriana, 2020; Wahab et al., 2021), while the nature of science is not only receiving knowledge but how students can discover knowledge from the practicum process.

LAD analysis of the digestive system from previous research has discussed the comparison of several LADs (Sari & Fuadiyah, 2022). However, it is limited to comparing several LADs without the LAD reconstruction stage. In addition, similar studies related to LAD analysis and reconstruction (Adiyanto et al., 2021; Zahra et al., 2021) discuss LAD analysis and LAD reconstruction of the digestive system in the form of food tests. At the same time, the LAD sample discusses the specifics of investigating carbohydrate foods, not the food test as a whole.

Therefore, it is essential to analyse and reconstruct the design of the laboratory activity 'Menyelidiki Makanan Berkarbohidra't. The aim is that practicum activities not only function as confirmation or verification but also can develop student skills to build student knowledge. This study aims to review and reconstruct the design of laboratory activities, especially on organ structure and function of digestive organs in the mouth in the context of carbohydrate digestion.

B. Material and method

This study uses a qualitative descriptive method to assess the quality of Laboratory Activity Design (LAD) and reconstruct it into a new LAD on the topic "Menyelidiki Makanan Berkarbohidrat". The sampling technique used was purposive sampling, and one LAD obtained from the biology book for class XI IPA SMA Kemendikbud independent curriculum on regulatory system material as the subject to be analysed.

This study followed the ATR (Analyse, Try, and Reconstruct) steps that Supriatno (2013) developed. At the analysis stage, LAD was analysed and assessed based on Novak & Gowin's (1984) practicum instrument listed in Table 2. LAD assessment calculated using Formula 1. Then, the percentage results are categorised based on the assessment criteria of Arikunto (2016), as shown in Table 1.

$$\text{score percentage} = \frac{\text{number of scores}}{\text{total score}} \text{x}100\% \text{....Formula 1}$$

Table 1 Assessment criteria

Scale (%)	Indicator
80-100	Very good
70-79	Good
60-69	Medium
50-59	Deficient
0-49	Very poor

After the analysis stage is complete, the next step is to conduct experiments in the laboratory using the LAD (Figure 1) without changing the tools, materials and procedures. The purpose of this stage is to observe the suitability of the practicum objectives with the learning outcomes of the independent curriculum. After obtaining the experimental results,

the next step is to reconstruct the LAD by repairing the LAD components and compiling them into a new LAD. Building student knowledge can show the suitability of the practicum objectives with learning outcomes. Experiments carried out following the reconstructed LAD, and the final stage was to improve LAD based on the reconstruction trial.

C. Results and discussion

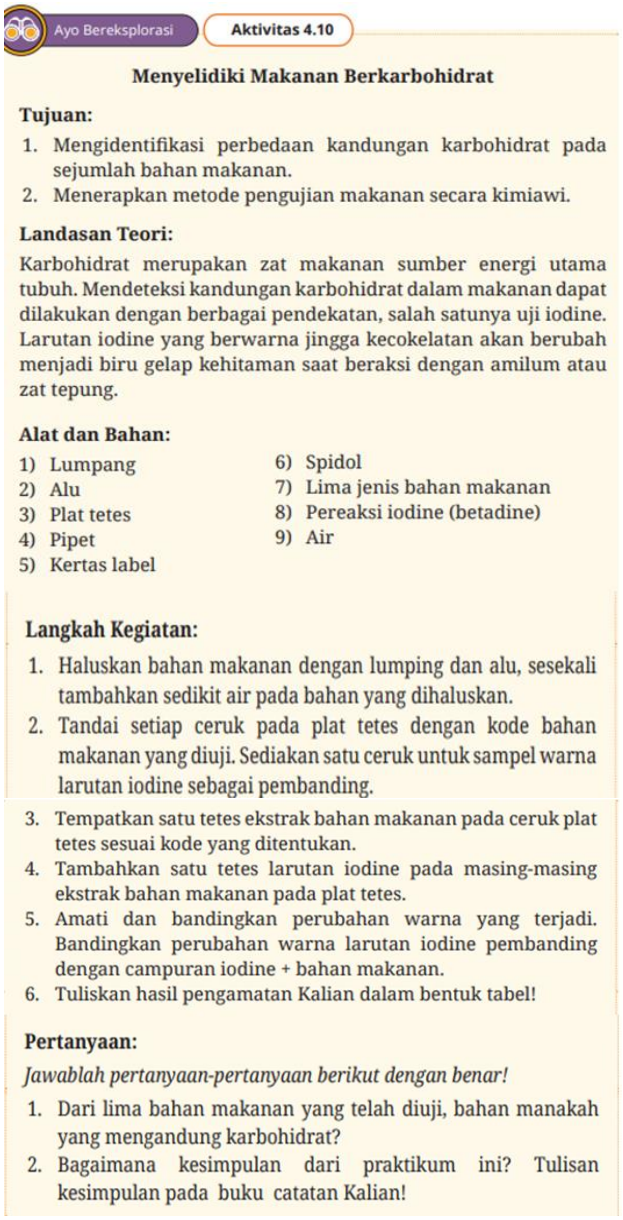
Laboratory Activity Design Analysis Stage

Laboratory Activity Design (LAD) was analysed by paying attention to aspects of the LAD instrument by Novak & Gowin (1984). The indicators considered are (a) focus questions, (b) objects, (c) theories, principles and concepts, (d) data recording or transformation, and (e) knowledge claims. The assessment instrument is presented in Table 2, while the score given is 0 for the lowest score and 4 for the highest score.

The components of the laboratory activity design that were analysed were the practicum objectives, the objects observed, the completeness of tools and materials, practicum procedures, recording data on practicum results (record data), and research questions. The scores obtained are summed up and then calculated based on the LAD assessment percentage formula to determine the assessment criteria of LAD. Then the percentage criteria are seen in Table 1. From the results of the LAD instrument analysis in Table 2, the total score of the LAD analysis was 7, with a percentage of 38.89%, where the LAD categorised as "Very less".

Table 2 LAD assessment

Score guide	Indicator	Score obtained
Focus question		
0	No focus question identified.	
1	Focus questions are identified but do not guide the acquisition of events/concepts.	1
2	The focus question identified and guided the generation of events/concepts; incorrect events result in incorrect data.	
3	Focus questions are identified and can be used to generate appropriate events and data.	
Object/event		
0	No objects/events identified.	
1	Key objects/events identified but not consistent with the focus question.	
2	Key events identified and consistent with the focus question.	2
3	Key events identified; consistent with focus question; can be used to record data.	
Theory/Principle/Concept		
0	No concepts identified.	
1	Concepts identified but without principles and theories.	1
2	Concept identified and one of the principles (conceptual/procedural); or relevant concept and theory identified.	
3	Concept and principles (conceptual and procedural) identified; or concept, one of the principles and relevant theory identified.	
Listing/Transformation		
0	No data recording/transformation identified.	
1	Data recording identified but not consistent with the focus question/event.	
2	One (recording/transformation) identified and consistent with the focus question/event.	2
3	Data recording/transformation identified; data record as per event; transformation inconsistent with a focus question.	
4	Recording and transformations identified; data recording appropriate to the event; transformations consistent with focus question; and lab activities appropriate to student level.	
Knowledge claims		
0	No knowledge claims identified.	
1	Knowledge Claims do not relate to concepts, principles and theories.	1
2	Knowledge Claims include concepts that can be used to correlate but are inconsistent with recording and transformation.	
3	Knowledge Claims include concepts that can be used to correlate and are consistent with recording and transformation.	
4	Knowledge Claims include concepts that can be used to relate; are consistent with recording and transformation; and can be used to create new focus questions.	
17	**Total score**	**7**



Ayo Bereksplorasi — Aktivitas 4.10

Menyelidiki Makanan Berkarbohidrat

Tujuan:

1. Mengidentifikasi perbedaan kandungan karbohidrat pada sejumlah bahan makanan.
2. Menerapkan metode pengujian makanan secara kimiawi.

Landasan Teori:

Karbohidrat merupakan zat makanan sumber energi utama tubuh. Mendeteksi kandungan karbohidrat dalam makanan dapat dilakukan dengan berbagai pendekatan, salah satunya uji iodine. Larutan iodine yang berwarna jingga kecokelatan akan berubah menjadi biru gelap kehitaman saat beraksi dengan amilum atau zat tepung.

Alat dan Bahan:

1) Lumpang
2) Alu
3) Plat tetes
4) Pipet
5) Kertas label
6) Spidol
7) Lima jenis bahan makanan
8) Pereaksi iodine (betadine)
9) Air

Langkah Kegiatan:

1. Haluskan bahan makanan dengan lumping dan alu, sesekali tambahkan sedikit air pada bahan yang dihaluskan.
2. Tandai setiap ceruk pada plat tetes dengan kode bahan makanan yang diuji. Sediakan satu ceruk untuk sampel warna larutan iodine sebagai pembanding.
3. Tempatkan satu tetes ekstrak bahan makanan pada ceruk plat tetes sesuai kode yang ditentukan.
4. Tambahkan satu tetes larutan iodine pada masing-masing ekstrak bahan makanan pada plat tetes.
5. Amati dan bandingkan perubahan warna yang terjadi. Bandingkan perubahan warna larutan iodine pembanding dengan campuran iodine + bahan makanan.
6. Tuliskan hasil pengamatan Kalian dalam bentuk tabel!

Pertanyaan:

Jawablah pertanyaan-pertanyaan berikut dengan benar!

1. Dari lima bahan makanan yang telah diuji, bahan manakah yang mengandung karbohidrat?
2. Bagaimana kesimpulan dari praktikum ini? Tulisan kesimpulan pada buku catatan Kalian!

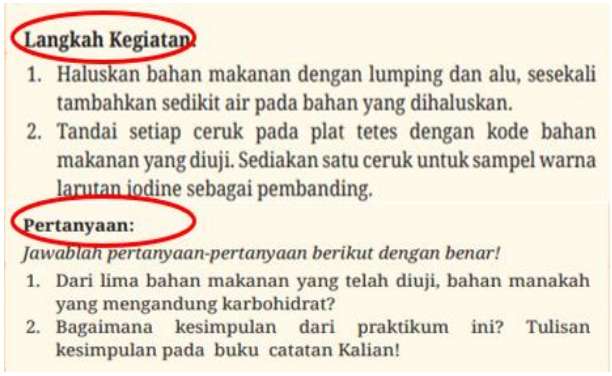
Figure 1
LAD "menyelidiki makanan berkarbohidrat" (in Indonesian)

Trial Stage

In the pilot stage, this research undertook a series of steps to evaluate the effectiveness of the initial LAD. Through investigating carbohydrate content according to LAD, researchers have been guided to conduct simple explorations, including introducing types of foodstuffs that contain carbohydrates and chemical testing of food substances that contain carbohydrates, as seen from the colour changes that occur.

However, the results of the analysis show that this approach is only a verification of some examples of foods containing carbohydrates and has not supported the construction of students' knowledge in a constructivist manner, as can be seen from the work steps and questions, only in the form of verification, and questions only in the form of conclusions, there is no process of leading to knowledge building (Figure 2).

Thus, there is still a need to improve some components of the LAD, such as the questions in the LAD. The questions provided are in the form of conclusion questions. It is necessary to improve the questions to encourage students' active involvement in knowledge construction.



Langkah Kegiatan:

1. Haluskan bahan makanan dengan lumping dan alu, sesekali tambahkan sedikit air pada bahan yang dihaluskan.
2. Tandai setiap ceruk pada plat tetes dengan kode bahan makanan yang diuji. Sediakan satu ceruk untuk sampel warna larutan iodine sebagai pembanding.

Pertanyaan:

Jawablah pertanyaan-pertanyaan berikut dengan benar!

1. Dari lima bahan makanan yang telah diuji, bahan manakah yang mengandung karbohidrat?
2. Bagaimana kesimpulan dari praktikum ini? Tulisan kesimpulan pada buku catatan Kalian!

Figure 2
LAD procedure and questions (in Indonesian)

Reconstruction stage

This stage of LAD reconstruction involved several essential improvements that systematically organised. First, the objectives of the practicum were adjusted to reflect the learning outcomes following the Merdeka Curriculum (Kemdikbud, 2022). The new practicum objective is to deeply understand the relationship between organ structure and function in the food digestion system. In this goal, students will conduct chemical food testing and understand the role of organ structure and function in carbohydrate testing.

The practicum steps will involve identifying food before and after it is digested in the mouth and guiding students to understand the process of breaking down the carbohydrate amylum into glucose. Furthermore, the tools and materials must added according to the practicum objectives and the object of observation. Finally, the practicum questions were also improved, and some questions added to direct the change of facts to more profound concepts (Figure 3).

Thus, this reconstruction expected to provide a more holistic and in-depth learning experience about the digestive system and enable students to develop a better conceptual understanding. The analysed LADs have provided questions, but the questions only lead to a verification, namely foodstuffs that contain carbohydrates and inference. The conclusion is to determine foods containing carbohydrates through colour change using an iodine solution. This question, in the form of inference, does not lead students to develop concepts (Hindriana, 2020). In addition to the focus question, the practicum objective component is essential to analyse (Millar, 2004). The sample LAD in the biology book grade XI Kemendikbud provides practicum objectives, namely to identify the carbohydrate content of food and the application of chemical food testing methods. The initial objectives

did not show the relationship between organ structure and organ function according to the learning outcomes in phase F (BSKAP Kemdikbud, 2022). So, the practicum objectives revised according to the learning outcomes. A new practicum objective obtained: knowing the relationship between the structure of organs and their functions in the digestive system through investigating carbohydrate foods. The LAD objectives adjust to the object or event to be identified (Millar, 2004).

Pertanyaan

1. Organ apa saja yang terlibat pada proses pencernaan di mulut?
2. Bagaimana proses pencernaan makanan di mulut?
3. Apakah terjadi perubahan makanan setelah dikunyah?
4. Apa saja yang menyebabkan perubahan tersebut?
5. Ketika mengunyah makanan di mulut apakah kamu dapat merasakan/mengecap makanan tersebut?
6. Apakah ada perbedaan warna setelah ditetesi Iodin pada makanan yang sebelum dikunyah (ekstrak yang dihaluskan menggunakan lumpang dan alu) dan setelah dikunyah?
7. Apakah terdapat perubahan pada makanan yang tidak dikunyah dan yang dikunyah setelah dipanaskan dan sebelumnya ditetesi larutan benedict?
8. Jika terjadi perubahan warna menurutmu apa yang menjadi penyebabnya?
9. Dari tabel hasil pengamatan buatlah kesimpulan berkaitan dengan peran organ pencernaan?

Figure 3 Question LAD reconstruction (in Indonesian)

Prosedur Percobaan

A. Uji Amilum

1. Sediakan 5 bahan makanan, lalu haluskan menggunakan 2 cara.
2. Haluskan 5 bahan makanan dengan lumpang dan alu, sesekali tambahkan sedikit air pada bahan yang sedang dihaluskan (cara 1)
3. Haluskan 5 bahan makanan dengan dicerna (dikunyah) dengan mulut (cara 2)
4. Siapkan dua plat tetes, satu untuk bahan makanan yang dihaluskan menggunakan lumpang dan alu, dan satu lagi untuk bahan makanan yang dicerna dengan mulut.
5. Tandai setiap ceruk pada plat tetes dengan kode bahan makanan yang diuji
   Plat tetes 1: Untuk bahan makanan yang dihaluskan dengan lumpang dan alu
   Plat tetes 2: Untuk bahan makanan yang dicerna dengan mulut (dikunyah)
6. Teteskan sebanyak satu tetes esktrak makanan pada setiap ceruk plat tetes sesuai tanda yang sudah dibuat.
7. Teteskan sebanyak satu tetes iodine pada ekstrak makanan pada plat tetes 1 dan 2
8. Catat dan amati perubahan warna yang terjadi pada tabel hasil pengamatan.

B. Uji Glukosa

1. Sediakan sebanyak 10 tabung reaksi, 5 buah tabung reaksi untuk makanan yang dihaluskan menggunakan lumpang dan alu, 5 buah tabung reaksi untuk makanan yang dicerna menggunakan mulut.
2. Tandai setiap tabung dengan label bahan makanan yang akan diuji.
3. Teteskan ekstrak bahan makanan kedalam 10 tabung reaksi sesuai label yang dibuat
4. Diencerkan dengan akuades kemudian diteteskan 5 tetes Benedict.
5. Siapkan kaki tiga dengan kasa asbes dan bunsen untuk proses pemanasan, letakkan beaker glass yang sudah diisi air panas, proses pemanasan bertujuan untuk mempercepat reaksi.
6. Masukkan tabung reaksi yang sudah ditetesi larutan Benedict kedalam beaker glass yang berisi ari panas selama beberapa menit atau hingga mendidih. Apabila sampel menunjukkan perubahan warna menjadi kuning, oranye, dan merah bata, maka sampel positif mengandung glukosa.
7. Amati dan catat perubahan warna yang terjadi!

Figure 4 Reconstructed LAD experiment procedure (in Indonesian)

The main object or event in the LAD has identified. The LAD also provides information on tools, materials and practicum procedures. The tools and materials are adjusted to the practicum objectives based on the trial. Tools and materials added on the reconstructed LAD according to the practicum

procedure. There is a procedure for testing glucose content using Benedict's solution, methylated spirits, and a beaker glass to observe colour changes that indicate glucose content after heating (Figure 4). The addition of tools and materials and work steps is adjusted so that students can observe the object. Student observation skills are closely related to the accuracy of work procedures and the suitability of materials (Rahmania et al., 2021).

The next stage is the data recording process, namely, recording data on object/event identification results. The previous LAD did not provide a place to record data and only gave orders for students to record the results of the identification of carbohydrate content in the table. Meanwhile, after the trial and reconstruction, the author provided a data recording table for the identification results of the data recording process with food samples that are digested using the mouth and not digested. Both samples tested using a glucose test and an amylum (polysaccharide) test.

As supported by Supriatno (2013), if students do not understand the results of their observations, the data transformation they do can result in incorrect relationships between concepts, so the decomposed principles become inappropriate. This is related to the findings of Novak & Gowin (1984), which show that data analysis and transformation can show the extent of students' understanding of the theories, principles, and concepts they encounter in their research results.

Transformation is needed to transform factual knowledge through observations made by students, in this case, based on data recording, into a concept. The transformation process was not visible in the previous LAD because the data recording method not explained in clear instructions. According to Solihat (2011), data transformation and analysis help students develop understanding and provide more profound answers to the core questions in the practicum task. After data recording, it expected that students can form a concept from the results of the carbohydrate food investigation. In the previous LAD, the concept of carbohydrates has provided. Students only need to determine foods containing carbohydrates from the results of the investigation. Practically, students no longer need to build their knowledge. Knowledge claims also do not occur because there is no process of leading the factual towards the emerging conceptual. Thus, the reconstruction of LAD provided gradual questions about the relationship between organ structure and function by investigating carbohydrate foods.

Reconstructed LAD

The observable phenomenon is the digestion process in the mouth with the help of specialised organs in sequence. In the mouth, there is a process of mechanical digestion of food using teeth and tongue. At the same time, chemical digestion uses salivary glands (Campbell & Reece, 2008). In the practicum, students observe changes in the shape and texture of food before and after digestion (chewing). Then conduct amylum and glucose tests using iodine and benedict solutions to see the carbohydrate content of food (Fitri & Fitriana, 2020; Hani et al., 2023; Fleischer, 2019). Based on the test results with iodine solution, the colour change in digested and undigested food is purplish blue, indicating the presence of amylum content.

Testing Benedict's solution requires a heating process to see the colour change. The results of colour changes can be yellow, green, or brick red, indicating that the solution contains glucose, and blue indicates that the solution does not contain glucose (Listyalina et al., 2020). From this phenomenon, students can see the difference in carbohydrate content in foods that are digested (chewed) and not. With successive questions, students invited to build concepts about the role of the structure of the digestive system organs with their functions on changes in the shape, texture and colour content of food.

According to Millar (2004), in practicum, two domains play a role: natural objects and objects that can observed in the domain of ideas. Analysis of practicum activities based on the purpose of the practicum is to increase students' scientific knowledge through learning a relationship in the form of a Domain of ideas related to learning a concept and a theory or model to solidify the knowledge that students have because students' initial knowledge is incomplete (see Figure 5).

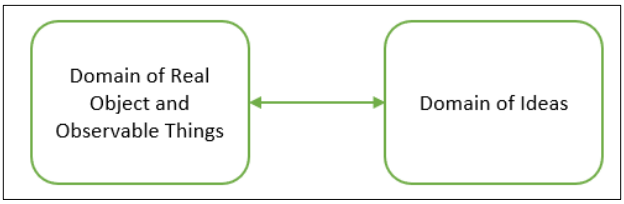


Figure 5
Object domain relationship with idea domain (Source: Millar, 2004)

Students will see the relationship between organ structure and function in the digestive system. The organs in the mouth consisting of teeth, tongue and salivary glands will more clearly illustrated by analysing the structure of the teeth, tongue and salivary glands and their role in the digestive process in the mouth and how the mouth plays a role in the digestive process. After learning the concepts and their relationships, students can integrate into their lives related to theories or models in biological science, and there is a connection with meaningful learning theory, where students can interpret the learning and understand that the digestive process is natural in students or occurs in the student's own body. Supported by the opinion of Rahmania et al. (2021) state that students will gain knowledge after doing practicum activities based on LAD.

D. Conclusion

Based on the results of the analysis and trial of LAD on investigating carbohydrate foods in Biology book SMA Class XI IPA used by teachers and students, the components did not support students' concept formation. The sample LAD is only for concept verification to determine what food ingredients contain carbohydrates from the materials tested. Based on the reconstruction results, the new LAD follows the curriculum objectives, and its stages can support the process of forming student knowledge so that it can used as a laboratory activity design in the practicum topic of investigating carbohydrate foods. Further research is necessary to see the effectiveness of the reconstructed LAD "Menyelidiki Makanan Berkarbohidrat".

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