



## Development of 21st Century Skills-Based Stereochemistry Learning Tools to Train Students' Argumentation Skills

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**Abstract:** This study aims to describe the validity of 21st century skills-based stereochemistry learning tools to train students' argumentation skills. This research is an educational design research with reference to the design of the Wademan development research model. The research instrument used was a learning tools validation sheet consisting of several validation sheets, namely: syllabus validation sheet, lesson plan validation sheet, teaching material validation sheet, student worksheet validation sheet, and argumentation skills assessment instrument validation sheet. The research data obtained from the validation and review sheets were analyzed descriptively and qualitatively. The expert's assessment of validation for each aspect of the assessment has good and very good validity criteria. These results indicate that learning tools that integrate the nature and complexity of the stereochemical structure of natural compounds from tropical rain forests can be used in the stereochemistry learning process.

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### Introduction

The development of science is based on progress in its field. By developing knowledge, one must be able to convince others through his discoveries. The findings must also be convincing through good quality argumentation. Scientists use arguments to relate the evidence they choose to claims obtained through the use of warrants and backings (Jim'enez-Aleixandre & Erduran, 2007). Argumentation is an important discourse process in science, and therefore should be implemented in science classrooms (Jiménez-Aleixandre et al., 2000; Kelly & Takao 2002).

The ability in argumentation must be followed by argumentation quality. Argumentation quality is defined as a condition of presence refutation issued by a student in a study (Erduran et al. 2004; Erduran et al. 2015 ). The quality of argumentation is significant in understanding the study and developing thinking skills, such as critical thinking. Someone who can think critically if able to analyze, understand, and evaluate argumentation inside study activity.

Argumentation is the process of developing, explain, and evaluate the scientific argument. A scientific argument based on a specific claim or statement is justified to supported proof or data (Nuttfield Foundation, 2013a). Argumentation is a reasoning strategy located in the domain of informal reasoning and critical thinking (Jim'enez et al., 2000; Jim'enez-Aleixandre & Erduran, 2007). Sampson and Clark (2008) differentiated with argument and argumentation by using "argument" that means the data used by student for articulate and justify claim or conclusion whereas "argumentation" to describe process

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overall. From differences meaning about argumentation, at least two points that combined in definition van Eemeren and Grootendorst relevant to science class contextual, which are argumentation as a justification of knowledge and argumentation as persuasion. Therefore, argumentation in scientific topics could be defined as the relationship between claim and data through justification or evaluation claim of expertise in proof, either empirically or theoretically (Jimenez-Alexandre and Erduran, 2007). Studies, including argumentation as challenging for students; as an example, students are always asked how to explain “ why and how things can happen” in the organized activity to involve students argue.

In the Covid-19 pandemic era, have occurred necessary changes in the implementation of organic chemistry study. Organic chemistry using the various symbol in representation which should understand by students (Taber, 2009), and the things impact on difficulties that faced students with understanding organic chemistry concepts (Bhattacharyya & Bodner, 2005; Ferguson & Bodner, 2008; Cartrette & Dobberpuhl, 2009; Kraft et al., 2010; Dwyer & Childs, 2011; Cartrette & Mayo, 2011; Cooper et al., 2012). Students usually tend to use a study approach oriented with memorization (Duffy, 2006). According to Garlich (2015), cognitive skills to understand organic chemistry were representational competency, spatial ability, and scientific reasoning strategy. In their research, Chin & Osborne (2010) mentioned that implementation from the thinking process and scientific reasoning process is argumentation. Understanding the relationship between scientific argumentation verbal and written were convinced can help fruitfulness in organic chemistry study (Pabuccu et al., 2012). The study focused on argumentation can increasing student conceptual comprehension (Venville & Dawson, 2010; Aydeniz et al., 2012; Walker & Sampson, 2013a; Cetin, 2014) and quality argumentation (Erduran et al., 2004; Garcia et al., 2013). The low argumentation skill influenced the low on chemistry concept comprehension (Cetin, 2014; Sekerci & Canpolat, 2014; Aydeniz et al., 2012). During the pandemic era, students much more obtained presentation materials from lecturers and tend only to wait for lecturer presentation slides and memorize the materials. These things impact on liveliness and argumentation strength from students. Consequently, it needed a study model to develop a student's argumentation strength in understanding organic chemistry subjects.

The development of organic chemistry syllabus directing material contents appropriate with Pola Ilmiah Pokok (PIP) Mulawarman University concentrated on natural resources, mostly tropical rain forest and its environment. As known as tropical rain forest as a warehouse of chemistry compounds, natural resources, particularly plants that exist inside it, are sourced from chemistry compounds in particular organic compounds that can be implemented as origin examples of subject material on organic chemistry I. For example, (+)/(-)-catechin isolated from stem bark of *Aglaia elliptica* (Meliaceae) and *Chisocheton pentandrus* (Meliaceae). Both of these plant species are found in Indonesia's tropical forest. The chirality and complexity of stereochemistry in natural products of rain forests can be used as learning resources in developing organic chemistry learning. So it's necessary to develop integrated organic chemistry learning tools PIP UNMUL based on 21<sup>st</sup> century skills to practice atudent argumentation skill, because with existence example that comes from the surrounding environment makes students have interest and comprehension better in argue skill in organic chemistry I subject.

## Research Method

Producing integrated stereochemical learning tools for UNMUL Principal Scientific Patterns (PIP) based on 21st-century skills to train students' argumentative skills as a valid (Nieveen, et al., 2007; Plomp & Nieveen, 2013) is the aim of this study. The learning tools



developed must be of high quality according to the validator's assessment, must be realistic and can be applied by lecturers and students. The learning tools' application produces the desired impact accompanied by positive student response to stereochemical learning tools. This research was conducted at Mulawarman University from October to December 2020. The scope of this research is Chemistry Education Department students enrolled in class I Organic Chemistry for the 2020/2021 academic year, totaling 100 students. The research focused on the stage of developing 21st century skills-based stereochemistry learning tools by qualitatively analyzing the results of the validator's assessment.

The researcher chose the Wademan development research model (Plomp & Nieveen, 2013) as a reference for developing stereochemical learning tools. This model illustrates that the approach and product (intervention) go hand in hand with the approach and theory (design principles). The term generic refers to the theory as a result of research that can describe intervention theory or design theory, namely the knowledge generated from research. Theoretical and empirical support is needed in the prototype design process to obtain information about the quality of interventions and design principles. Formative evaluation exists as an essential feature and is placed in educational design research from the model developed by Wademan (in Plomp & Nieveen, 2013). The researcher chose this model to design the stereochemical learning tools developed in this study. The steps to build the Wademan model include 1) identification of the problem, 2) tentative identification of the product and design principles, 3) tentative theory and product, 4) prototyping and assessing product quality, and 5) improving product quality.

Experts use the instrument in the form of a validation sheet to assess the learning tools' quality being developed. Experts review and evaluate the quality of each component of each learning device. The instrument for measuring this learning device's validity consists of several validation sheets: the syllabus validation sheet, the lesson plan validation sheet, the teaching material validation sheet, the student worksheet validation sheet, and the assessment instrument validation sheet. The average score for each aspect calculates the data obtained from the validation of learning tools by experts. The technique of analyzing the validity of the learning tools uses descriptive qualitative.

**Table 1. Evaluation Criteria for the Validation of Stereochemical Learning Tools**

Score Interval	Assessment criteria	Information
3.25 < P 4.00	Very valid	Can be used without revision
2.50 < P 3.25	Valid	Can be used with minor revisions
1.75 < P 2.50	Invalid	Can be used with multiple revisions
1.00 P 1.75	Very invalid	Not yet usable and still requires consultation

(Adaptation of Ratumanan and Laurens, 2006)

The reliability of the learning tools validation sheet is determined based on the Percentage of observer agreement (Borich, 2003) by looking at the learning tools validation sheet's consistency when used to validate by the validator. The learning tools developed were then applied to organic chemistry learning online. Learning uses synchronous platforms such as zoom meetings and asynchronous such as WhatsApp group, Mulawarman University Online System (MOLS), YouTube, and Google Forms. The response questionnaire is used to determine student responses to the use of the learning tools developed. The results of the questionnaire were analyzed descriptively qualitatively.

## Results and Discussion

The stereochemistry learning tools developed to consist of syllabus, lesson plans, teaching materials, student worksheet, and argumentation skills assessment sheets. The results of expert assessments of learning tools were carried out on content validity, construct validity, and the use of language in stereochemical material.

### 1). Results of the validation of the syllabus

A summary of the validation analysis results for each component of the syllabus is shown in Table 2.

**Table 2. Results of Syllabus Validation**

No.	Assessment Aspects	Validation Score	Criteria	Reliability Coefficient (%)	Reliability
1.	Format	3,27	Very valid	89	Reliable
2.	Contents	3,54	Very valid	95	Reliable
3.	Language	3,89	Very valid	95	Reliable

The criteria for the validity of the syllabus validation components based on Table 2 all met the very valid criteria. The level of consistency between experts on all parts of the syllabus validation is very high.

The syllabus can be used as a guide in preparing a learning framework in the form of lesson plans, teaching materials, student worksheets, and assessment sheets (Fink, 2012; Ludy et al., 2016). The components of a validated syllabus include: 1) A syllabus is made for each meeting; 2) Syllabus identity (title, study program, courses, semester, number of credits, and learning outcomes); and 3) Format of syllabus table (expected final ability, indicators, learning experience, subject matter, time allocation, learning resources, and assessments, and references). The developed syllabus format component accommodates the Regulation of the Minister of Research, Technology and Higher Education of the Republic of Indonesia Number 44 of 2015 concerning National Higher Education Standards, which requires a description of the learning outcomes of KKNi graduates, namely, includes a description of attitudes and values, workability, mastery of knowledge and authority and responsibility.

### 2). Results of the validation of the lesson plan

The results of the validation analysis for each component of the lesson plan are shown in Table 3.

**Table 3. Results of Lesson Plan Validation**

No.	Assessment Aspects	Validation Score	Criteria	Reliability Coefficient (%)	Reliability
1.	Format	3,60	Very valid	92	Reliable
2.	Contents	3,39	Very valid	97	Reliable
3.	Language	3,78	Very valid	95	Reliable

Based on Table 3, the lesson plan validation components' validity all meet the very valid criteria. The level of consistency between experts on all elements of the lesson plan validation is very high.

The lesson plan is developed based on the syllabus, describes, and directs learning activities to achieve the expected learning outcomes and final abilities. RPP is a plan that describes and regulates the learning process to achieve one of the basic competencies in the syllabus (Ahmad and Nur, 2015). The learning steps in the lesson plans developed have been



adapted to argument-based online learning. The lesson plan communicates to students what they will learn and how they will be assessed and helps lecturers organize content, materials, time, strategies, and assistance in the classroom by coordinating learning components so that learning objectives, learning materials, how to deliver activities (method, models and techniques) and how to evaluate them are clear and systematic so that the teaching and learning process becomes effective and efficient (Susantini, 2009; Ahmad & Nur, 2015; Widodo, 2017). The RPP developed has fulfilled the form of a good learning plan based on SNPT and KKNI (Kemendikbud, 2014; Widodo, 2017), which states that the lesson plan includes: 1) RPP identity (title, department, study program, course, semester, subject matter, number of credits, meetings too, time allocation, learning outcomes), 2) Systematics of RPP content (expected final abilities and indicators, learning stages, learning activities, approaches/models/methods, media, time allocation, learning resources, assessment, and Bibliography).

### 3). The results of the validation of teaching materials

A summary of the validation analysis results for each component of the teaching material is shown in Table 4.

**Table 4. Results of Teaching Material Validation**

No.	Assessment Aspects	Validation Score	Criteria	Reliability Coefficient (%)	Reliability
1.	Format	3,60	Very valid	92	Reliable
2.	Contents	3,39	Very valid	97	Reliable
3.	Language	3,78	Very valid	95	Reliable
4.	Presentation	3,78	Very valid	95	Reliable
5.	Assessment of teaching materials in supporting innovation and improving the quality of teaching and learning activities	3,50	Very valid	90	Reliable

The validity of the components of the validation of teaching materials is based on Table 4, all of which meet the very valid criteria. The level of consistency between experts on all components of the validation of teaching materials is very high.

Teaching materials are essential learning materials in the learning process to help students understand concepts and make it easier to achieve each student's competencies (Prasetyo & Perwaningtyas, 2017; Ilma and Wijarini, 2017; Ningsih et al., 2018). Stereochemical teaching materials are integrated with PIP Unmul, which is equipped with several examples of the structure of secondary metabolite compounds derived from wet tropical forest plants. Some features are expected to help students understand the material and practice argumentation skills. In the feature "let's understand," students are reminded of the material studied so that students can set the learning objectives carried out. In the "let's look at" feature, students are given examples of problems whose argument solutions are presented in a graphic organizer. In the "let's find out" feature, students are encouraged to carry out investigative activities with their friends' group. Meanwhile, the "let's test understanding"



feature is a student activity that tests the student's ability to argue in understanding the material that has been studied. Student responses show 68.18% of students are quite easy to use components in teaching materials. This means that the developed teaching material can help practice argumentation skills in students. In line with the research results of Sari et al. (2017) and Alberida et al. (2018), which revealed that the use of teaching materials developed according to the materials and skills that will be taught to students during the learning process could improve the expected skills compared to conventional teaching materials. As many as 80.03% of students felt interested in using teaching materials. Students also stated that stereochemistry teaching materials were new (81.31%). This data indicates that students are interested in reading teaching materials and motivated to learn more. This is in line with the research of Wulanzani et al. (2016) and Adalikwu & Iorkpligh (2013), which stated that students' interest in reading teaching materials is because teaching materials can act as facilitators between lecturers and students and develop student motivation during learning activities.

The teaching materials developed are based on learning outcomes and final abilities in the stereochemical syllabus. The development of such teaching materials is following the opinion of Mulyasa (2007) and Wulanzani et al. (2016), which state that the teaching material developed must be able to support the learning process and display the integrity of the competencies that will be mastered by students in learning activities so that it can help the achievement of course competencies. Development of stereochemical teaching materials based on the KKNI-based curriculum, which refers to the description of the learning outcomes of KKNI graduates, namely, including descriptions of attitudes and values, workability, mastery of knowledge and authority, and responsibility. The development of teaching materials that are under the curriculum is based on the opinion of Cardoso et al. (2009), which states that teaching material is the main link not only between lecturers and students but also between learning objectives because the teaching material in it seeks to translate the principles proposed by the curriculum, the teaching material contains content and activities that students can assimilate. The developed student teaching material can be used to improve argumentation skills because there are features specifically designed to practice these skills. The arguing skills-based teaching material developed is in line with the guidelines for preparing learning tools and teaching materials of the Ministry of Research, Technology and Higher Education (2017) that the appropriateness of the content of teaching materials can develop life skills.

#### 4). Results of student worksheet validation

A summary of the validation scores for each component of the student worksheet is shown in Table 5.

**Table 5. Results of Student Worksheet Validation**

No.	Assessment Aspects	Validation Score	Criteria	Reliability Coefficient (%)	Reliability
1.	Format	3,83	Very valid	93	Reliable
2.	Contents	3,33	Very valid	97	Reliable
3.	Language	3,89	Very valid	95	Reliable
4.	Presentation	3,25	Very valid	93	Reliable
5.	Assessment of teaching materials	3,24	Very valid	90	Reliable



in supporting  
innovation and  
improving the  
quality of teaching  
and learning  
activities

The expert's assessment of the validation of the developed student worksheets is valid and very valid. The level of consistency between experts on all components of student worksheet validation is very high.

Stereochemistry student worksheets were developed by integrating Unmul's PIP. Student worksheets with examples of structures for secondary metabolites from tropical wet forests. Student worksheets are designed with activities that encourage students to do argumentation skills according to the directions contained in student worksheets and understand chemical materials. The activities carried out by students in student worksheets include: identifying chemical problems, formulating problems, proposing hypotheses, formulating learning objectives, carrying out investigative activities, making arguments, presenting chemical arguments, and making conclusions. Graphic organizer chemistry arguments made by students in making arguments are characteristics of student worksheets that can practice argumentation skills. As stated by Bulgren and Ellis (2012), graphic organizers provide space for each step of the argumentation process. Student worksheets developed according to the material and skills framework that will be taught to students are needed in the learning process so that activities carried out by students can be directed (Supeno et al., 2015). Student worksheets can direct student learning activities to help students understand the material, solve problems, and help students discuss (Kibar & Ayas, 2010; Demoin & Jurisson, 2013). Development of student worksheets is carried out based on learning outcomes, final abilities, and indicators on the syllabus and stereochemical lesson plans. Developing student worksheets must be done by paying attention to the lesson plans and syllabus that have been developed (Widodo et al., 2018). Students feel interested in using student worksheets (75.25%); students also state that stereochemistry student worksheets are quite easy to use (66.62%). This data shows that students are interested in using student worksheets because they state that the students' worksheets are new (81.31%). This is because student worksheets are also equipped with references to read more about the material discussed (Susanti et al., 2018).

##### 5). The validation results of the argumentation skills assessment sheet

A summary of the assessment sheet validation for arguing skills is shown in Table 6.

**Table 6. Validation Results of the Argumentation Skills Assessment Sheet**

No.	Assessment Aspects	No. Questions	Validati on Score	Criteria	Reliability Coefficient (%)	Reliability
1.	Theory	1	3,50	Very	86	Reliable
		2	3,33	valid	90	Reliable
		3	3,42	Very	90	Reliable
		4	3,42	valid	90	Reliable
		5a, 5b	3,42	Very	86	Reliable
				valid		



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				Very valid		
				Very valid		
2.	Instructions	1	3,50	Very valid	93	Reliable
		2	3,50	valid	93	Reliable
		3	3,50	Very valid	93	Reliable
		4	3,67	valid	100	Reliable
		5a, 5b	3,50	Very valid	93	Reliable
				valid		
				Very valid		
				Very valid		
3.	Language	1	3,42	Very valid	90	Reliable
		2	3,50	valid	93	Reliable
		3	3,42	Very valid	90	Reliable
		4	3,42	valid	90	Reliable
		5a, 5b	3,50	Very valid	93	Reliable
				valid		
				Very valid		
				Very valid		
				valid		

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The expert's assessment of the validation of the argumentation skills assessment sheet developed has very valid criteria. The level of consistency between experts on all components of the validation skills argument is very high.

The argumentation skills assessment instrument is designed by integrating the Unmul PIP. The questions in the assessment instrument contain the structures of secondary metabolites from wet tropical forests. The argumentation skills assessment instrument adapts the assessment developed by Venville & Dawson (2010). The argumentation skills developed include indicators of claiming claims, data, and guarantees. The Argumentation Skills assessment sheet's validation, as shown in Table 6, is included in the very valid and reliable criteria. Referring to the opinion of Kereh et al. (2015), Kurnia et al. (2017), Muhtarom et al. (2017), Muslim et al. (2017) which states that there are at least two basic characteristics that can be used as a reference for the quality of an instrument, namely reliability, and validity. The instrument is developed if it meets the valid and reliable criteria for the next stage of operational field testing or measurement. Thus the instrument of argumentation skills developed can be used to measure students' argumentation skills.

The learning tools developed to consist of syllabus, lesson plan, teaching material, student worksheets, argumentation skills assessment sheet. The results of expert assessment of stereochemistry learning tools are carried out on content validity, construct validity, and language use, with each assessment aspect having good and outstanding validity criteria. Further research can be carried out to test the practicality and effectiveness of stereochemical learning tools to improve students' argumentation skills.





## Conclusion

PIP UNMUL's integrated stereochemistry learning device has been declared valid both in content and construct. It can be used in stereochemistry learning, exploring, and empowering student potential through argumentation activities to teach stereochemical concepts.

## Recommendation

Further research can be carried out by researchers and educators to test the practicality and effectiveness of stereochemistry learning tools to improve the argumentation skills of chemistry students. The innovations carried out by integrating the UNMUL PIP, namely humid tropical forests and a 21st century skill-based environment are expected to be an alternative solution to improve students' argumentation skills.

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