Developing POGIL-based worksheets of chemistry and unity of sciences

M Zammi1,* K Khoiriyyah2, T Wibowo1, U Lathifa1, A Fibonacci1

1Departement of Chemistry Education, Faculty of Sciences and Technology, Universitas Islam Negeri Walisongo Semarang, Indonesia
2SMK Futuhiyyah, Demak, Indonesia

*Corresponding author: zammi@walisongo.ac.id

Abstract. The development of POGIL-based worksheets of Chemistry and Unity of Science is an obvious step to reduce the existence of dichotomy on Students of UIN Walisongo Semarang. Media and Learning Sources used have not facilitated students in inquiry and UOS-contained activity. Therefore, the purpose of this research is to produce POGIL-based worksheets on Chemistry and unity of sciences and to decide the worksheets quality. Meanwhile this research method uses Research and Development with 4D by Thiagarajan. Validation sheets and Response Questionnaires are the instruments of Data Collection. The developed Worksheets are validated by material and media experts with the results of validation 89% and 88.33% in which the developed worksheets are valid and proper to be used. Otherwise, the response of students to the worksheets is good with the average percentage of questionnaire results 83.46%, the worksheets do not need to be revised. Hence, the proper-developed worksheets are used as the supported learning media for students.

1. Introduction
State Islamic University of Walisongo is an Educational institution which committed and consistent to unity of sciences vision. This great vision should be a motor to “civitas academica” especially students to learn any science without discrimination. This is in line with Islamic Fitrarah that religious and general sciences come from and lead to “The Creator” [1]. However, students could not understand this noble vision until now, the students consider that religious and general sciences are two contradictory entity, religious and general sciences stand on its own corridor, and the religious science is more urgent than general science. Hence, it creates the dichotomy of sciences indirectly.

The implementation of unity of science paradigm is a solution to reduce the dichotomy, students need to understand that religious science which come from Qur’an and Hadith give contribution to the character and moral building for students [2]. Therefore, this implementation paradigm could be realized with the integration of Qur’an as a source of confirmation [3]. This implementation paradigm should be conducted until the process of learning step because in this learning process the lecturer and the students are able to interact and communicate each other in educative way to reach the learning purpose [4]. Learning Process place source and media of learning as the main factor. Learning media are triggered to motivate students
Learning, convert the complex concept to simple concept, and abstract to be concrete and easier to understand [5].

Learning media is very diverse and fulfilled the students necessary [6]. However, the use of learning media is supposed to be adjusted with the students learning way [7, 8]. This purpose is to enhance motivation and to stimulate students [9, 10]. The Questionnaires Data relating to students necessary collected on pre-research had shown that learning style on 2018 grade chemistry students were 70,50% visual, 15,50% auditory, and 14,00 kinesthetic. Not only learning style, but the learning source and media are supposed to fulfil the students-centred activity in order that students are able to find and to construct the concept of learning material [11]. Therefore, learning materials supposed to be used are the media which likely to visual learning style with students’ activities as well as inquiries. One of them is printed media namely students’ worksheet (SW). SW is one of printed learning media which is constructed to facilitate students to build cognitive, psycho motoric and affective aspects by giving some particular notes and to facilitate students to get involved in learning process [12]. SW is able to be used as supportive learning material which encourage students to master chemistry materials [13].

Good and Ideal Students’ Worksheets are those which fulfilled material and contained students’ activity with cognitive process involvement, inquiry activity to enhance understanding of the concept, problem solving and students’ responsibility. Based on survey conducted by chemistry education students grade 2018, the understanding of students is still low. The understanding of concept in salt hydrolysis is obviously important for students. It is essential that this salt hydrolysis involve the students’ ability especially on another material like Bronsted-Lowry acid base concept [14]. Therefore, students often faced difficulties to find out the inconvenient concepts or even misconception [15, 16]. This phenomenon is caused by learning source and media which spread over more emphasize to problem and solution of mathematic counting, lack of learning source which emphasize to understanding of the concepts [17], chemistry as clump of science contains abstract concept, specific chemical reaction mechanism, mathematical count as well as involving multi-level representation [18]. Otherwise, learning process which only equip students with basic ability and focus on lecturer also become causative factors on the low understanding of concepts and students’ interest [19]. This ignorance situation is going to affect students to be passive in learning process, unwilling to get involved in inquiry activities so that affects on low understanding and ability of concept invention. Whereas, through inquiry learning process it is able to improve students learning seriousness [20], thinking ability [21], concept understanding [22] and lead students to construct their understandings [23]. Concept Understanding plays important role in learning activity as results of its ability to make students reach their learning results and response life’s problem. Hence, SW is needed to lead and guide students in concept invention and application namely POGIL.

POGIL facilitates students in learning especially in information-digging activity and invent concept [24]. POGIL consists of three steps; Exploration, concept invention and application [25, 26]. Image Presentation and inquiry in exploration step are able to stimulate students’ thinking to develop a certain concept. In invention concept, students are guided and pushed to invent concept by producing prediction and conclusion. Therefore, in application step, students are able to implement concept which is understood into new situation [24, 27].

POGIL implementation in learning process encourages students to be more active [28], to increase their self-esteem and performance [29], to be responsible, to study using their best potency [24], to facilitate students to understand abstract concepts [23], improve understanding of concepts [30], improve higher order thinking skills [31], and to help students actively in teamwork [32], to train students to do several activities like scientists do buy using communicative-collaborative skills [33]. By using POGIL, students are considered to be more responsible to their tasks, to study using their high level thinking ability, to improve their performance to the learning materials and to develop positive relationship with other students [24]. Implementing interactive-cooperative learning enables students to communicate their idea, to solve
problems and to construct knowledge independently [2, 34]. Based on the description, POGIL-based worksheets and Unity of Sciences are supposed to be developed as learning media.

2. Method
Model of Development in this research is Research and Development with 4-D model which is adapted by S.Thiagarajan, Dorothy S. Semmel and Melvyn I. Semmel. This 4-D model consists of 4 steps: 1) Define; 2) Design; 3) Develop; 4) Disseminate [35]. 4D Model Development is used to produce and to gain product development such as POGIL-based Worksheets and Unity of Sciences. Steps in 4-D Development model need to be implemented systemically. Development steps can be viewed at Figure 1.

Define step is implemented to gain information and to decide the needs as well as to collect information related to developed product opportunities. Define step consists of Front-end analysis, Learner Analysis, Task Analysis and Concept Analysis. Design step is intended to construct worksheets prototype based on necessary analysis result conducted in the define step. Design step consists of Media Selection, Format Selection and Initial Design. Initial Design of this research is product construction (prototype) with media and format which have been designed with the structure of curriculum analysis result and material on major of chemistry education. Initial design is then discussed/appraised with scientist/expert.
Develop step is conducted to collect or to produce product which has been discussed with the expert and been revised [36]. This step consists of (a) Expert Appraisal, in this step appraisal and feasibility test of the product (prototype) is conducted by experts based on their specialties. Material Validation consists of “content feasibility aspects, literature and presentation technique’. Media Validation consists of “physical appearance and functional aspect’. Content Validation unity of sciences consists of “science-islam integration aspects, scientific spirituality in islam and literature”. Worksheets which have been considered valid by experts are tested afterwards to collect advice and insight from the users related to the quality of product and the product weaknesses.

This research is conducted in UIN Walisongo Semarang, with 4th semester students of chemistry education as the subject of the research. Technique of data analysis uses experts appraisal and response questionnaires of students on the worksheets. Worksheets appraisal is decided by the result of empirical validation with specified validity criteria. Scores are then converted towards validity criteria in Table 1 [37]. Meanwhile the data collected based on response questionnaires of chemistry education students on developed worksheets are presented afterwards based on response criteria. Scores collected are compared response criteria in Table 2 [38].

### Table 1 Validity Criteria of Worksheet

| No | Validity Criteria (%) | Level of Validity                          |
|----|-----------------------|--------------------------------------------|
| 1  | 85.01 – 100           | Valid                                      |
| 2  | 70.01 – 85            | Valid Enough/able to be used with little revision |
| 3  | 50.01 – 70            | Less valid, need much revision             |
| 4  | 1.0 – 50              | Not valid/ unable to be used               |

### Table 2 Response Criteria

| No | Score level (%) | Category     |
|----|-----------------|--------------|
| 1  | 86 – 100        | Very Good    |
| 2  | 76 – 85         | Good         |
| 3  | 60 – 75         | Enough       |
| 4  | 55 – 59         | Less         |
| 5  | 0 – 54          | Very less    |

### 3. Result and Discussion

Products of this research are chemistry worksheets with POGIL and unity of sciences model adoption on salt hydrolysis material. POGIL steps in the worksheets are able to change perception that chemistry concepts and materials are identical with counts which contained formula and complicated/abstract concepts to be understood by students more easily [23], to help students actively in teamwork [32], to train students to do several activities like scientists do buy using communicative-collaborative skills [33]. This is because POGIL enables students to conduct exploration, to invent and apply concepts [24–26] in salt hydrolysis material. Moreover, the developed worksheets contain unity of sciences by elaborating chemistry sciences and religious sciences with Qur’an as the basis, students acknowledge that sciences are actually united which come from The Creator. Therefore, it is able to reduce the existence of dichotomy among academists [2] to improve intention and to understand chemistry science easier [39]. This Integrated Implementation is able to be conducted by using Qur’an verses to confirm scientific phenomena in the end of learning process [3].

Worksheets prototype which have been produced in design step are later discussed with experts to be validated. The validation of the experts consists of POGIL basis, Unity of Sciences content. Tabel 3 shows
that each Validator in worksheets validation tests such as content of the worksheets, POGIL and Unity of Sciences are valid. Meanwhile, students response towards developed worksheets of every category is good (83.46%). Not only the entire response but the analysis of response results is also conducted to each aspects such as “easy to understand, learning independently, learning actively, worksheets presentation, worksheets usage, unity of sciences contemplation and POGIL steps aspects”. Results of students response analysis on each aspects are able to be viewed on Table 4.

Developed worksheets facilitate students to construct cognitive, psychomotor and affective aspects by giving some particular notes and to facilitate students to get involved more actively in learning process [12], to be supportive learning media which improves students’ concepts mastery regarding with chemistry material [13]. Contents of POGIL facilitate students in learning process especially in collecting information activity and inventing concepts [24]. POGIL consists of three steps such as exploration, concept invention and application [25, 26]. Image presentation and inquiry in exploration step are able to stimulate students’ thoughts to develop a certain concept. By using interactive-cooperative activity, students are able to communicate idea, to solve problems and to construct knowledge independently [34]. Meanwhile, the content of unity of sciences shares new knowledge to students that sciences are actually united and centred on The Creator. Therefore, POGIL-based worksheets and UOS are able to be implemented as supportive learning media for students.

| No. | Components                          | The Score of Validator | Criteria |
|-----|-------------------------------------|------------------------|----------|
|     |                                     | I   | II  | mean |               |
|     | Content expert                      |     |     |      |               |
| 1.  | Content eligibility                 | 88% | 92% | 90%  | Valid         |
| 2.  | Language                            | 80% | 100%| 90%  | Valid         |
| 3.  | Presentation technique              | 90% | 90% | 90%  | Valid         |
| 4.  | POGIL content                       | 85% | 95% | 90%  | Valid         |
| 5.  | Basis Unity of Sciences             | 80% | 90% | 85%  | Valid         |

|     | Media expert                        |     |     |      |               |
|     | Worksheet presentation              | 95% | 85% | 90%  | Valid         |
| 2.  | Eligibility and graphics            | 93% | 87% | 90%  | Valid         |
| 3.  | Display quality                     | 80% | 90% | 85%  | Valid         |

| No. | Respondents | Student Response | Categories |
|-----|-------------|------------------|------------|
| 1   | R-1         | 76.92            | Good       |
| 2   | R-2         | 88.46            | Very good  |
| 3   | R-3         | 88.46            | Very good  |
| 4   | R-4         | 86.15            | Very good  |
| 5   | R-5         | 76.92            | Good       |
| 6   | R-6         | 76.92            | Good       |
4. Conclusion

The conclusion of the conducted research showed that this research produces POGIL-based chemistry worksheets and Unity of Sciences as supportive learning media for students with valid category and students’ respond is categorized good. The worksheets need to be tested more comprehensive to find out the effectivity and the effect towards students using understanding concepts.

References
[1] Nata A, Suwito, Masykuri A and Armai A, 2005 Integrasi Ilmu Agama dan Umum (Jakarta: Rajagrafindo Persada)
[2] Hamzah F 2016 Studi Pengembangan Modul Pembelajaran Ipa Berbasis Integrasi Islam – Sains Pada Pokok Bahasan Sistem Reproduksi Kelas IX Madrasah Tsanawiyah Adab. J. Pendidik. Islam 1 41
[3] Minarno E B 2017 Integrasi Sains-Islam dan Implementasinya Seminar Nasional Teknologi Informasi, Komunikasi, dan Industri (SNTKI) 9 Fakultas Sains dan Teknologi UIN Sultan Syarif Kasim Riau (Riau: Pekanbaru) p 664
[4] Rustaman N 2007 Ilmu dan Aplikasi Pendidikan (Bandung: PT. Imperial Bhakti Utama)
[5] Asnawir and Basyiruddin Usman 2002 Media Pembelajaran (Jakarta: PT. Ciputat Pers)
[6] Ardenson R H 1976 Selecting & Developing Media for Instruction (Wescosin: American Society for Training and Development)
[7] Musfiqon 2012 Media dan Sumber Belajar (Jakarta: PT. Prestasi Pustakaraya)
[8] Chania Y, Haviz M, Sasmita D, Sudirman J, Kubu N and Limokaum R 2016 Hubungan Gaya Belajar dengan Hasil Belajar Siswa pada Pembelajaran Biologi Kelas X SMAN 2 Sungai Tarab Kabupaten Tanah Datar Journal of Saintek 8 77–84
[9] Azhar A 2007 Media Pembelajaran (Jakarta: PT Raja Grafindo Persada)
[10] Kustandi, C and Sutjipto B 2011 Media Pembelajaran Manual dan Digital (Bogor: Ghalia Indonesia)
[11] Fajri L, Ashadi A and Utomo S 2016 Pembelajaran Hidrolisis Garam Menggunakan Model Inkuiri Terbimbing Dan Process-Oriented Guided Inquiry Learning (Pogil) Ditinjau Dari Kemampuan Analisis Dan Rasa Ingin Tahu Inkuiri 4 10–8
[12] Kaymakci S 2012 A Review of Studies on Worksheets in Turkey. Online Submiss. US-China Education Review 1 57–64
[13] Senam, Arianingrum R, Permansari R L and Suharto 2008. Efektivitas Pembelajaran Kimia untuk Siswa SMA Kelas XI dengan Menggunakan LKS Kimia Berbasis Life Skill J. Didaktika 9 280 - 290
[14] Wiyono G P 2011 Identifikasi Konsep Sukar dan Kesalahan Konsep Asam-Basa Bronsted-Lowery pada Siswa Kelas XI SMA Negeri 1 Malang Tahun Ajaran 2010/2011 Thesis (State University of Malang)
[15] Quliyah B 2012 Identifikasi Persepsi Konsep Sukan dan Kesalahan Konsep Hidrolisis pada Siswa
Kelas XI SMA Negeri 5 Malang Thesis (State University of Malang)

[16] Seçken N and Alşan E U 2011 The effect of constructivist approach on students’ understanding of the concepts related to hydrolysis Procedia - Soc. Behav. Sci. 15 235–40

[17] Lin H 1998 The effectiveness of teaching chemistry through the history of science J. Chem. Educ. 75 1326 – 1330

[18] Ristiyani E and Bahriah E S 2016 Analisis Kesulitan Belajar Kimia Siswa Di Sman X Kota Tangerang Selatan J. Penelit. dan Pembelajaran IPA 2 18

[19] Simbolon D H and -- S 2015 Pengaruh Model Pembelajaran Inkuiri Terbimbing Berbasis Eksperimen Riil dan Laboratorium Virtual terhadap Hasil Belajar Fisika Siswa J. Pendidik. dan Kebud. 21 299

[20] Chase A, Pakhira D and Stains M 2013 Implementing process-oriented, guided-inquiry learning for the first time: Adaptations and short-term impacts on students’ attitude and performance J. Chem. Educ. 90 409–16

[21] Ningsih S M and Bambang S 2012 Implementasi Model Pembelajaran Process Oriented Guided Inquiry Learning (POGIL) Untuk Meningkatkan Kemampuan Berpikir Kritis Peserta didik. Unnes Physics Educ. Journal 1 44

[22] Sarjana I K D and Margunayasa I G 2016 Pengaruh Model Pogil, Gaya Kognitif, Dan Motivasi Berprestasi Terhadap Pemahaman Konsep Ipa Siswa Kelas V Sd J. Pendidik. dan Pengajaran 49 21

[23] Barthlow M J 2011 The Effectiveness of Process Oriented Guided Inquiry Learning to Reduce Alternate Conceptions in Secondary Chemistry Dissertation (Liberty University)

[24] Hanson D M 2006 Instructor’s Guide to Process-Oriented Guided-Inquiry Learning (Stony Brook: Stony Brook University)

[25] Moog, R. & James S 2008 Process Oriented Guided Inquiry Learning (POGIL) (Washington DC: American Chemical Society.)

[26] Mitchell E and Hiatt D 2010 Using POGIL techniques in an information literacy curriculum J. Acad. Librariansh. 36 539–42

[27] Widiawati I 2013 Upaya meningkatkan Keterampilan Proses Sains Siswa melalui Strategi Pembelajaran POGIL pada Materi Laju Reaksi di Kelas XI SMA Negeri 36 Jakarta (Jakarta)

[28] Şen Ş and Yılmaz A 2015 the Effects of Process Oriented Guided Inquiry Learning Environment on Students’ Self-Regulated Learning Skills Probl. Educ. 21st Century 66 54–66

[29] De Gale S and Boisselle L N 2015 The Effect of POGIL on Academic Performance and Academic Confidence Sci. Educ. Int. 26 56–79

[30] Khulliyah K and Fadlan A 2019 Penguasaan Konsep dan Retensi Melalui Pogil (Process Oriented Guided Inquiry Learning) Bermuatan Multiple Level Representation JEC J. Educ. Chem. 1 36–43

[31] Jacobs G 2006 Cooperative Learning and Second Language Teaching (Cambridge: Cambridge University Press)

[32] Arends R L 2008 Learning to Teach (Yogyakarta: Pustaka Pelajar)

[33] Thiagarajan; Dorothy S. Semmel and Melvin I. S. 1974 Instructional Development for Training Teachers of Exceptional Children (Bloomington: Indiana University)

[34] Trianto 2009 Mendesain Model Pembelajaran Inovatif-Progresif (Jakarta: Kencana Prenada Media Group)

[35] Akbar S 2013 Instrumen Perangkat Pembelajaran (Bandung: PT. Remaja Rosdakarya)
[38] Ngalim P 2002 *Prinsip-prinsip dan Teknik Evaluasi Pengajaran* (Bandung: PT. Remaja Rosdakarya)

[39] Zammi M and Hakim F 2020 The Development Stoiciometry Module Based on POGIL and Unity of Sciences *J. Phys. Conf. Ser.* **1539**.

**Acknowledgements**

The authors gratefully acknowledge financial support form BOPTN LP2M UIN Walisongo 2020. The reviewer form LP2M for the suggestion in this research.