An Automatic Approach for Identifying Triple-Factor in e-Learning Process

Sfenrianto, Zainal A. Hasibuan, and Heru Suhartanto

***Abstract*—Developing the personalization in an e-Learning environment is a way to provide learning material which matches the students' characteristics. In order to develop an e-Learning which supports personalization should be designed to facilitate an factors influence the success of students' learning, such as learning style, motivation, knowledge ability, etc. Considering the existence of those factors for the personalization in e-Learning system can affect students' performance and makes learning easier for them. Therefore, in this study, we propose a parameter (learning behavior patterns) based on learning activities (learning behavior) students for identifying learning styles, motivation, and knowledge ability (triple-factor) in e-Learning system. Our approach is to identify the triple-factor by simply observing his/her learning behavior recorded in data log, without asking the student to answer any questions of questionnaire. Each data log gives an indication related to identification the triple-factor in e-Learning system. The identification of those factor aims at inferring the learning styles, motivation and knowledge ability states. Then, it uses as the basis for dynamic personalization functionality.**

***Index Terms*—E-Learning, learning behavior, identification, personalization, learning style, motivation, knowledge ability.**

I. Introduction

Conventional learning and e-Learning have different characteristics in terms of interaction frequency. In conventional learning, teachers and students are more often interact directly in the classroom, while the e-Learning is more common in online learning. Thus, in conventional learning, teachers can easily see how their students learn (learning activities). However, in the e-Learning (Learning Management System-LMS), teachers have more difficulties to know how learning activities (learning behavior) students in a course [1].

In the LMS, information about learning behavior should be used to identify the factors influence the success of students' learning, such as learning style, motivation, knowledge ability, etc. The identification of those factors aims to support learning personalization for students. The personalization in e-Learning system is as a strategy which very useful to adjusted students needs, so make they learn more effectively.

In order to support personalization, our previous study in [2] [3], indicates that the existence of inherent structure that reflect relationship among learning style, motivation and knowledge ability (Triple-Characteristic Model or Triple-Factor).

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Considering triple-factor in the e-Learning system is studied by some previous researches who argue the importance of those factors in learning process. For instance: according to Khan *et al.* in [4], affective states and learning styles tactics to provide personalize in e-learning system have a significant effect on student learning. According to Graf *et al.* in [5], By providing personalization based on the identification of student' learning style, less study time to achieve on average same grade (e.g. Graf, and Kinshuk, 2007) and higher student satisfaction (Popescu, 2008) have been demonstrated. Then, knowing the information students' learning style can be used to provide student with learning material/activities and personalized recommendations than fit with their learning style [1]. In relation to research on motivation, log activity has also been considered as a source of information for assessing students' motivation [6].

Hence, many researchers agreed that adopting personalization based on students' learning styles and motivation in e-learning will increases knowledge ability and makes learning easier for them. However, previous studies conducted using different factor. We also do not see a comprehensive approach identification that reflects the relationship between learning style, motivation, and knowledge ability for personalization learning materials.

In this study, we focus on identifiying triple-factor based on learning behavior students for dynamic personalization in e-Learning process (LMS). The paper is structured in the next sections as follows: related study and preliminary study are described; subsequently, identifying triple-factor based on learning behavior patterns; last section concludes our study.

II. Related Study

This section, we explains the related study. The first section related with the Triple-characteristic Model (TCM). Subsequently, about Triple-Factor in e-Learning process. The last explains the methode for identifying students' characteristics in e-Learning.

A. Triple-Characteristic Model (TCM)

In order to support personalization, the result of our previous study in [2], we have proposed the Triple-Characteristic Model (TCM) in e-learning system. It accommodates students' learning style, motivation and knowledge ability in their personalized learning activities.

Fig. 1, the TCM consists of three layers, i.e. learning layer, characteristic layer, and personalization layer. The relationship between the three layers are learning layer which

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provides learning behavior patterns to support identification of students' characteristics on characteristic layer. Then, it provides the basis for personalization functionality on personalization layer.

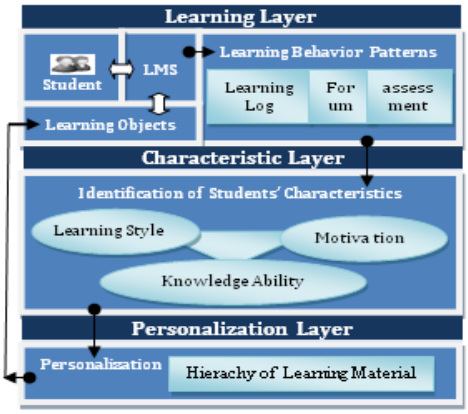

Fig. 1. Triple-Characteristic Model (TCM) [2]

Learning layer includes four components, they are students, Learning Managemen System (LMS), learning objects, and learning behavior patterns. The students will interact with the e-Learning system through LMS in order to gain the learning materials that suit their needs, forum for discussion, take all the tests, etc. The LMS is e-learning software as well as an organizer of the learning objects (materials, forums, tests, etc.) and a tool to provides information about students learning behavior patterns in an online learning situation.

The information of learning behavior patterns is stored and managed in a data log (learning log, forum log, and test result). A Learning log contains learning behavior patterns, such as the number of content access, link of content reference, etc. Then, the log of forum discussion consist of the number of visits to the forum, number of posting, reply forum, and how long to stay in the forum. Whereas, assessment comprises scores test or grade, upload_assignment, and attempt_quiz.

In the characteristic layer is design to explore the identification of students' characteristics (learning style, motivation, and knowledge ability). In order to identify them, it uses a learning behavior patterns in the data log as mentioned earlier. These patterns will indicate learning style and motivation (learning behavior pattern in learning log and forum log) and the student knowledge ability (using assessment of the course).

The result from this identification can be used to generate personalization. The personalization layer provided a hierarchy of learning materials that suit to student's learning style, motivation, and knowledge ability.

B. Triple- Factor in e-Learning Process

Then in the previous study [3], we also proposed the influence factors of inherent structure in e-Learning process. The result of our study as shown in Fig. 2, indicates that the existence factors of inherent structure that reflect relationship among learning style, motivation and knowledge ability.

Our approach integrates information about learning styles, motivation and knowledge ability factor, in order to enable e-Learning system to identify and personalise the learning materials based on those factors. Thus, in the e-Learning process, triple-factor must be identified for the purpose of personalized learning materials, recommendation to students and make students learn more effectively.

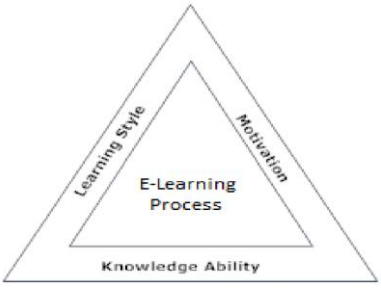

Fig. 2. The Influence factors of inherent structure in e-Learning Process [3]

C. Identifying Students' Characteristics in e-Learning

To identify students characteristics in an e-Learning system has based on some data about learning style, motivation, and knowledge ability, etc. The methods of gathering those data can employ direct questions or learner-system interaction (automatic approach) [7].

Using direct questions approach, can be collected through questionnaire. For example, Index of Learning Style (ILS) can be used to instrument for identifying learning styles based on the Felder Silverman Learning Style Model (FSLSM).

On the other hand, automatic approach which observed the behaviour of students during an online course in e-Learning. The Approach makes use of student's interaction based on student's learning behaviour (data log learning activities) during an online course. Analyzing and interpreting data log learning activities is a valuable source of information about student's learning behavior, i.e. the number of content access, number of posting, reply forum, and how long to stay in the forum, upload_assignment, attempt_quiz etc. Based on this information, data about students' behaviour can be used to indentify hints for specific learning style preferences, degrees of motivation, and knowledge levels. For example, if a learner often posting, reply in the forum discusstion, etc. This information gives us a hint that the student is a higher degree of motivation in a course.

The advantage of direct questions approach is its simplicity, the questionnaire can be applied directly in e-Learning system. Students are required to answer the questions provided. Based on their answers students' characteristics can be inferred. However, disadvantages of this questionnaire can be seen in the number of too many questions (e.g. the ILS have 44 questions). It is difficult to motivate the students to fill out the questionnaires, it implies a supplementary workload for students, students may tend to choose answers arbitrarily instead of thinking carefully to answer questions, etc. The main limitation of this method is static, so the students characteristics stored once, without the possibility to be updated [8]. Therefore, the automatic approach can solve these weaknesses. An automatic approach can be dynamically adapt the characteristic of a student changed over time [9].

Several studies have been used to automatic approach, such as: (1) Graf, *et al.* (2007), an automatic approach for detecting learning style preferences according to the Felder-Silverman learning style model (FSLSM), which can be used to identify the FSLSM learning style based on

learning behavior of the students in LMS Moodle [9]; (2) Bahiah and Mariam (2008), providing parameters for identification of FSLSM learning style dimension from e-Learning activities[10]; (3) Khan, et. al. (2010), an automatic identification for affective states and learning styles in web-based learning management systems [11]; (4) Hamada, et. al (2011), behavior analysis in e-Learning environment to identify the suitable learning style [12]; Dung and Florea (2012), an approach for detecting FSLSM learning styles in learning management systems based on students' behaviours [13].

In this studi, we propose an automatic approach for identifying learning style, motivation, and knowledge ability (triple-factor) based on learning behaviour patterns, which helps to bring learning personalization in e-Learning system (LMS). We will analysis to determine the parameters of learning activities students can used to identify their learning style, motivation and knowledge ability (triple-factor) in e-Leaning process.

III. Preliminary Study

The identification and personalization in e-Learning environment involves very complicated processes. Hence, we have held a preliminary study to analyzing learning activities (learning behavior) in order to support identification and personalization based on triple-factor in e-Learning process. The expected results of this study are parameters that represent the learning behavior as basis for indentify learning style, motivation, and knowledge ability in e-Learning process.

This study is reviewed in the next section as fellow: the first section details about data are shown. Last section, analysis and interpretation.

A. Data

In order to determine which parameters of learning activities the students can be used to identify their learning style, motivation and knowledge ability, we have held study at Faculty of Computer Science, University of Indonesia (Fasilkom UI). Preliminary data for this study are extracted from a undergraduate course on Research Methodology & Scientific Writing. The course was taught to inter-university, and offers online learning that can be taken by any student of the participating universities. The name of the program is Global Development Learning Network (GDLN) Indonesia 2011. The participating universities are: University of Indonesia, Islamic University of Indonesia Yogyakarta, STMIK MDP Palembang, and STMIK Kharisma Makassar.

In this course, one hundred and eighty-six (186) students were involved in the 15-weeks-course through Student Centered E-Learning Environment (SCELE), which was developed by e-learning team at Fasilkom UI [14]. This subject is selected as samples because the availability of resources, and learning activities in the e-learning, sufficient to represent a parameter to identify learning styles, motivation, and knowledge ability of students.

During the learning, the students were required to interact with the SCELE through variety of features (i.e. resource, forums, quizzes, and assignments) to gain the learning materials, to support interactive learning and participated in forum discussion, take all the on-line quizes, and submitted assignments. Every activities performed by the students, such as: the frequency of accessing learning materials (i.e. syllabus, slide, audio, video, animation, example, feedback, bonus_point and reference), the student's involvement in forum, on-line quiz, and doing assignments were recorded and stored in data log.

As shown in Table I, we gathered data of the learning activities of students to access resources, forums, quizzes, and assignments in SCELE system.

TABLE I: The Data of Learning Activities In SCELE System Based On Access Features

Features	Learning Activities of SCELE	Data Log	
		Total	%
Resources	Syllabus	201	0,60
	Slide	6419	19,27
	Video	2465	7,40
	Audio	2756	8,27
	Animation	2286	6,86
	Example	2167	6,51
	Reference	1759	5,28
	Feedback	1874	5,63
	Bonus_point	1762	5,29
Forums	Posting	121	0,36
	Replay	191	0,57
	View	10515	31,57
Quizzes	Attempt	125	0,38
Assignments	Upload	667	2,00
	Total	**33308**	**100,00**

Then as shown in Table II, we also gathered the data of the learning activities of students that used SCELE system based on test score.

TABLE II: The Data Activities of SCELE Based on Test Score

Test Score	Activities of Learning Log		Activities of Forum Log		Activities of SCELE	
	Total	%	Total	%	Total	%
Excellent (86-100)	10257	30,79	5738	17,23	15995	48,02
Good (76-85)	6205	18,63	3604	10,82	9809	29,45
Average (66-75)	3819	11,47	1473	4,42	5292	15,89
Poor (0-65)	1654	4,97	558	1,68	2212	6,64
Total	21935	65,86	11373	34,14	33308	100,00

B. Analysis and Interpretation

Several researchers have used the approach of Felder-Silverman Learning Style Model (FSLSM) to identify learning styles based on the student behavior and interaction while learning on-line [9]-[11]. However, this behavior which was selected based on different needs because the availability of resources and differences in online learning environment. This study, we also utilize the FSLSM to investigate the student's preferences (behavior) of the resources and forums. The reason behind choosing this model is that there is enough literature about it. Then it is used often in research related to learning styles in e-Learning, as one of the adaptability than tailors to learning differences

and individual needs [15], [16].

The FSLSM can be categorized into four dimensions for each student (active/reflective, visual/verbal, sequential/ global, and sensing/intuitive) [9]. In table I, shows the existence several those dimensions based on preferences of students in e-Learning process (SCELE). The analysis and interpretation are described in more detail for each learning style dimension, as follows:

Active students, tend to learn actively with working together with others. Whereas reflective students, learn by thinking things through learn alone. According Graf et. al. (2009) in [1], discussion forum can give indications about the students' preference for active or reflective learning. More specifically, active students are expected to spend more time on forum (time_forum), respond to discussion topics (reply_forum), and to add number topics in the forum (posting_forum) more often in order to ask, discuss, and explain something. Meanwhile, reflective students are prefer to participate passively by carefully and frequently reading the postings (view_forum) but only rarely posting by themselves. In addition, reflective students like to think about the material through learn alone, they are expected to learn more example (view_example), and animation material (view_anamation). On the other hand, active students are supposed to learn a few examples and animations because they prefer to do something with others. In Table I, Although their activity is still low (posting_forum 121 activities or 0,36%, and reply_forum 191 activities or 0,57%), students perform activity only more often the view_forum (10515 activities or 31,57%). Then view_example (2167 activities or 6,51%) and view_animation (2286 activities or 6,86%). Those data indicated the existence of type active and reflective students. Therefore, posting_forum, reply_forum, view_forum, time_forum, view_example, and view_animation can be used as learning behavior patterns for identifying an active or reflective learning style in e-Learning.

Visual students, remember best what they have seen (video, animation, etc.). Whereas verbal students, easy to remember the thing what they hear and written. Thus, visual students are expected to learn better from video (view_video), and animation (view_animation). On the other hand, verbal students are expected to visit reading materials such as slide presentation (view_slide) and audio (view_audio). Based on data In Table I, preferences for view_video (2465 activities or 7,40%), view_animation (2286 activities or 6,86%), view_slide (6419 activities or 19,27%), and audio_view (2756 activities or 8,27%). Therefore, view_video, view_animation, view_slide, and view_audio can be used as learning behavior patterns for identifying an visual or verbal learning style in e-Learning.

Sequential students, tend to lean by exploring the material in sequence. Whereas global students, are not interested in obtaining details of the materials being presented but, they like to get an overview of the materials. Thus, sequential students more preference in details material, such as: access the material in a linear (linear_content), and access to reference material (link_reference). While global students tend to be more interested in overview (view_outline), and sometimes skipping or jumping to more complex material (leaps_content). In Table I, the student's preferences of the syllabus (201 activities or 0,60%), and reference matrials (1759 activities or 5,28%) was considered as another learning behavior patterns for identifying an seguential or global learning style in e-Learning.

Sensing students tend to learn from concrete material or like examples (view_example). Sensing students also usually work carefully and slowly can be predicted through number of access contents, such as view_slide and link_reference. Whereas intuitive students, prefer to learn abstract material (view_outline) and like challenges, with tend to solving each assignments (upload_assignment), quizzes (attempt_quiz). In Table I, from all activities in SCELE system the students have uploaded 125 assignments activities or 0,38%, and attempted 667 quizzes or 2,00%. Therefore, the explanation of sensing and intuitive learning style, we should consider view_example, view_slide, link_reference, view_outline upload_assignment, and attempt_quiz can be used as learning behavior patterns for identifying those learning style in e-Learning.

On the other hand, several approaches for motivation strategies in e-learning process have been used and suggested. Using forum participation and assessments as motivational tools in e-Learning courses[17]. Then according to Keller & Suzuki in [18], motivational strategies used to increase student satisfaction, such as rewards, personal attention, feedback, etc. Whereas McCleskey [19], recommending a strategy to enhance students motivation in e-learning can be use visual interest (photographs, video, graphics, and animations). Thus the approach motivational strategies in e-learning possibly might vary depending on the needs of the learning environment of institutions.

In previous study [20] as shown in Fig 3, we have consider six strategies as trigger factors to motivate studens in e-Learning process, namely: discussion forum, giving assignments, online quizzes, feedbacks, bonus points, and multimedia learning materials. Those strategies are expected to trigger students to be actively involved in e-Learning process. Thus, a student with high or low motivation state can be indicated from the number of learning activities in e-Learning process.

Based on the previous study [20], the students with high or low motivation state in e-Learning can be indicated from learning activities of SCELE system:

Discussion forum (posting_forum, reply_forum view_ forum, and time_forum).

Assignments (upload_assignment).

Online quizzes (attempt_quiz)

Feedbacks (responding feedback)

Bonus points (responding_bonus)

Multimedia (view_slide, view_video, view_audio and view_animation).

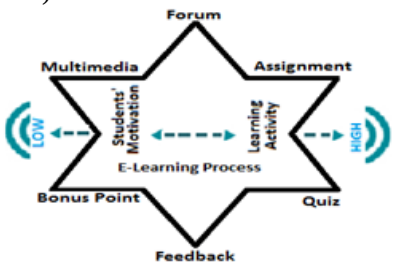

Fig. 3. Six Strategies as Trigger Factors to Motivate Studens in e-Learning Process [20]

TABLE II: THE PARAMETERS OF LEARNING BEHAVIOR PATTERNS BASED ON COMMONLY FEATURES FOR IDENTIFYING TRIPLE-FACTOR IN E-LEARNING PROCESS.

Features	Learning Behaviour Patterns	Learning Style FSLSM								Motivation		Knowledge Ability	
		Active	Reflactive	Visual	Verbal	Sequential	Global	Sensing	Intuitive	MHigh	MLow	KHigh	KLow
Forums	Posting_ Forum	**H**	**L**							**H**	**L**		
	Reply_ Forum	**H**	**L**							**H**	**L**		
	View_ Forum	**L**	**H**							**H**	**L**		
	Time_ Forum	**H**	**L**							**H**	**L**		
	Responding _Feedback									**H**	**L**		
	Responding _Bonus									**H**	**L**		
Resources	View_ slide			**L**	**H**			**H**	**L**	**H**	**L**		
	View_ Video			**H**	**L**					**H**	**L**		
	View_ Audio			**L**	**H**					**H**	**L**		
	View_ Animation	**L**	**H**	**H**	**L**					**H**	**L**		
	View_ Outline					**L**	**H**	**L**	**H**				
	View_ Example	**L**	**H**					**H**	**L**				
	Link_ Reference					**H**	**L**	**H**	**L**				
	Linear_ Content					**H**	**L**						
	Leaps_ Content					**L**	**H**						
Assignments	Upload_ Assignment							**L**	**H**	**H**	**L**		
	Score_ Assignment											**H**	**L**
Quizzes	Attempt_ Quiz							**L**	**H**	**H**	**L**		
	Score_ Quiz											**H**	**L**

Then in the context knowledge ability, many researchers agreed that adopting personalization based on learning styles and motivation in e-learning will increases knowledge and makes learning easier for students. In table II, we can see that there is relationsip between the number of learning activities and test score in SCELE system. It can be see from tests score obtained by students, which indicated from the category of their knowledge ability: (85-100) Excellent (15995 activities or 48,02%); (75-84) Good (9809 activities or 29,45%); (65-74) Average (9809 activities or 15,89%); and (0-64) poor (2212 activities or 6,64%).

Thus, from data investigation and analysis results, shows that there is a tendency that the higher the frequencies of activitees in SCELE, the higher the test score the students will get. Thus, we also interpreting that identification of knowledge ability can be indicated from tests score or grade obtained such as: score_assignment, and score_quiz.

IV. IDENTIFYING TRIPLE-FACTOR BASED ON LEARNING BEHAVIOUR PATTERNS

In this section, we are proposed an approach the relevant learning behavior patterns for identifying each FSLSM learning style dimension, motivation, and knowledge ability (triple-factor). The approach based on from the result of the analysis and interpretation in the previous subsection. Table III lists the parameters of learning behavior patterns which based on commonly features in e-Learning system. Each of those parameters can be used to indentifying triple-factor. Then, it provides the basis for personalization functionality.

We focused on commonly used features in LMS, such as: forums (F_1), resources (F_2), assignments (F_3), and quizzes (F_4). The features can be provides information about the learning behavior patterns for identifying triple-factor. These patterns are also called observable parameters. The parameters of the learning behavior patterns considered for indentifying triple-factor:

F_1 = {posting_forum (B_1), reply_forum (B_2), view_forum (B_3), time_forum (B_4), responding_feedback (B_5), responding_bonus (B_6)}.

F2 = { view_slide (B_7), view_audio (B_8), view_video (B_9), view_animation (B_{10}), view_outline (B_{11}), view_example (B_{12}), link_references (B_{13}), liner_content (B_{14}), leap_content (B_{15})}

F3 = {upload_assignment (B_{16}), score_assignment (B_{17})}

F4 = {attemp_quiz (B_{18}) , and score_quiz (B_{19})}.

In the context of indentifying triple-factor, a student (S), and behaviour (B) are the set of the learning behavior patterns that characterize student S. Thus, B(S) $\subset$ B_Triple-Factor, where B_Triple-Factor are the set of the learning behavior patterns included in triple-factor. Specifically, B_Triple-Factor = {B_1, B_2, B_3, ..., B_{19}}.

Whereas, for a student (S), and category (C) are C(S) $\subset$ C_Triple-Factor, where C_Triple-Factor is the set of the chategories included in triple-factor. Specifically, C_Triple-Factor = {Active (C_1), Reflective (C_2), Visual (C_3), Verbal (C_4), Seguential (C_5), Global (C_6), Sensing (C_7), Intuitive (C_8), MHigh (C_9), MLow (C_{10}), KHigh (C_{11}), KLow (C_{12})}. Categories C_Triple-Factor are grouped with two dimension. Dim_Triple-Factor = {C1/C2, C3/C4, C5/C6, C7/C8, C9/C10, C11/C12}. Thus a student (S) can only represented one of the two opposite categories, e.g. if $C_1 \in$ C(S) then C2 $\notin$ C(S).

Further, the identification of triple-factor category is based on the learning behavior patterns (B_Triple_Factor = {B_1, B_2,..., B_{18}}. The high ("H") or low ("L") occurrence of these patterns indicates each category in triple-factor. For the hight category denote by H_C and the opposite low category L_C. Each the patterns of learning behavior are $H_c/L_c \in$ B_Triple-Factor = {B_1, B_2,...,B_{19}}. Specifically for the High/Low of active/revlective category are H_{c1}/ $Lc_1 \in$ {B_1, B_2, B_3, B_4, B_{10}, B_{12}} and in the same manner also applies to other categories triple-factor.

The approach for calculating hints the the patterns of learning behavior (H/L) can be used to thresholds which proposed by Graf, Kinshuk, and Liu [1] or Garc á, Amandi, Schiaffino, and Campo (2007) in [8]. Those recommends thresholds can be changed if necessary. For instance: based on the assumptions of Garc á et al., the thresholds which recommended for visiting resourcesa were set to 75% -100%

(H) and <75% (L) of all available resources. Whereas, according Graf, et al. 10%-20% (H) and 20% (L). In our study, no recommendation is available for all thresholds triple-factor.

V. Conclusion

In this study, we have explained related study and a preliminary study to analyzing learning activities (learning behavior) in order to support an approach automatic for identifying triple-factor in e-Learning process. Based on the approach, we propose the relevant learning behavior patterns as parameters for identifying each FSLSM learning style, motivation, and knowledge ability (triple-factor) it provides the basis for personalization learning materials. The parameters of the learning behavior patterns are dynamically which changed over time, no need for students to fill out a questionnaire to get their learning style, motivation, and knowledge ability. Our future research is to implement the parameters in e-learning process in order to automatically identify triple-factor.

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