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The Beliefs towards Science Teaching Orientation of Pre-service Teachers in Primary Teacher Education Programme

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ABSTRACT

The present research seeks to describe the beliefs of pre-service trainee teachers in Primary Teacher Education Programme with regard to science teaching orientation. Respondents consisted of 100 sixth (introductory-level), and 120 eight semester (advanced-level) students in a Primary Teacher Education Programme. They came from different high school backgrounds such as science, non-science, and vocational education. Beliefs towards science teaching orientation cover aspects such as specific science curriculum, knowledge of student understanding of science, knowledge of instructional strategies, and knowledge of assessment of science literacy. Data were collected with the use of a 23-item questionnaire using a 4-point Likert scale – ranging from agree to disagree. Advanced level and introductory level students had significant effects on beliefs although gender and different high school backgrounds did not differ in terms of beliefs about science teaching orientation. Therefore, results indicated the belief of pre-service teachers is an important aspect to support science teaching orientation. The pre-service teachers must master the STO component to succeed as science teachers in Primary Education Programme.

Keywords: Beliefs, pre-service, Primary Teacher Education Program, science teaching orientation

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INTRODUCTION

The quality of science learning in primary schools is regarded as being effective and efficient if students are exposed to meaningful learning experiences that reflect their real-life situations. National Science Education Standards (National Research Council, 1996) emphasise the use of inquiry in integrated science learning. The quality of teaching needs to be ensured, as does the output of qualified teachers. Teacher education does not always consistently produce qualified teachers, and this leads to a lack of qualified teachers (EACEA, 2012).

Pedagogical Content Knowledge (PCK) makes a big contribution to the development of the quality of teachers and of teacher education (Kind, 2015; Williams & Lockley, 2012; Shulman, 1986). PCK research proposes several theories, which are then developed and adjusted to regional conditions. Friedrichsen, Driel, Van and Abell (2011) stated that the orientation of science teachers is one component of PCK that requires special attention. The teaching orientation enables improvement in the understanding of the quality of teachers. Science teaching varies for each subject matter and is adjusted to students' progress.

Teachers' beliefs and Science Teaching Orientation (STO) are important parts of educational research. Beliefs in science learning are developed through scientific inquiry. Prospective primary school teachers have the opportunity to develop their beliefs in science learning (Shim, Young, & Paolucci, 2010; Rahimah, Abu, Ismail, & Mat Rashid, 2014). Teaching experience provides prospective teachers with an understanding of how to teach science (Lay & Khoo, 2012; Yang, Tzuo, Higgins, & Tan, 2012). According to research conducted by Diblase and McDonald (2005), a teacher's background, experience, and confidence in teaching can be applied in the classroom. Orientation from Anderson and Smith (1987) to describe a teacher's "general patterns of thought and behaviour" is flexible and alterable. Flexible stance changeable by specific circumstance and alterable can be conducted by improving teacher's knowledge of science content and students' misconceptions.

Teachers need to understand the differences in students' individual characteristics, and respond empathetically to their students. For a teacher, teaching skills are required in science learning. Teachers' basic characteristics, including their beliefs, may affect students' learning outcomes, especially in science (Ak & Özkarde, 2007; Jong & Hodges, 2013; Mweene, Frackson, & Jonathan, 2011). According to some scholars, the concept of Pedagogical Content Knowledge (PCK) as a knowledge and skill distinguishes one teacher from another (Shulman, 2000; Williams & Lockley, 2012). Teachers have to master the concept of PCK in order to be able to deliver materials/subjects.

Several studies of Shulman's PCK models have been developed by educational researchers, one of which is Magnusson's model (Abell, Rogers, Hanuscin, Lee & Gagnon, 2009; Kind, 2015). It is a compilation theory of research and curriculum development, covering the aspect of teaching components including teaching orientation, knowledge of assessment of science learning, knowledge of instructional strategies, knowledge of students' understanding of science, and knowledge of specific science curriculum. These five components of teaching were then developed into nine indicators.

A science teacher is responsible for preparing the learning process and the knowledge of science to help students understand scientific concepts (McComas, Clough, & Almazroa; 1998). Teachers' and pre-service Teachers' (PST) belief in science is very helpful in teaching science to the students. Johnson (2006) stated that the teachers' beliefs, values, and attitude will be improved if they apply the inquiry learning method. Teachers with experience and a deep understanding of science will have more confidence to deliver science materials. Teachers' beliefs, by definition, are their perspectives with regard to the learning process, which are obtained from their own experience and observation. Value refers to the teachers' understanding of the benefits or usefulness of the investigation. Belief is defined as a trust or confidence when implementing inquiry in science learning (Diblase & McDonald, 2015).

Lederman, Abd-El-Khalick, Bell, and Schwartz (2002) stated that students should acquire certain belief about science as a feature of scientific knowledge. These include the belief that scientific knowledge is empirical, and that observations and scientific theories are internally consistent explanatory systems which guide research and investigations. Lederman (1999) observed the attitude and belief of pre-service teachers in the learning process. The teachers made use of their creativity and imagination during the learning process. The research proves that the teachers' beliefs affects the level of students' understanding. Foley and Mcphee (2008), and Nikula (2015) examined four primary teachers whose belief level increased after doing scientific practicums. They concluded that there is a relationship between hands-on and minds-on learning.

Beliefs have stronger affective and evaluative loading than knowledge. Nespor (1987) used four criteria to separate belief from knowledge. These are existential presumption, alternativity, affective and evaluative loading, and episodic structure. Existential presumptions are personal truth, such as a belief in gods or aliens based on chance or intense experience. Alternativity means the creation of fantasy worlds without direct experience. Kind (2015) argued that the affective and cognitive aspects of beliefs operate independently, but both influence learning. Episodic memory acts as a mental depository of past experiences which can impact on the present. Episodic memories may lead to a teacher replicating teaching received as a child or utilising external experiences, such as working as a research scientist.

In addition to coursework, pre-service teachers often engage in multiple field experiences (e.g., observations, practical, internships, student teaching) that provide opportunities for the evolution of beliefs about science teaching and learning. While universally seen as valuable, teacher trainers and pre-service teachers often face the dilemma of "bridging the cultures of the school and the university" (Jong & Hodges, 2013).

According to Magnusson, Krajcik and Borko (1999), science teaching orientation (STO) is defined as knowledge and beliefs regarding the purposes of teaching based on children's stages of development or general methods of viewing, or creating a science teaching concept. STO is the main component of Pedagogical Content Knowledge in guiding how pre-service teachers should teach. Magnusson et al.'s definition proposes that STOs comprise knowledge and beliefs and determine teachers' classroom actions. The nature of "knowledge and beliefs" in this context requires consideration. McComas, Clough and Almazroa (1998) noted that science teachers are responsible for providing an "accurate description of the function, processes and limits of science", arguing that the knowledge of the nature of science (NOS) helps students learn scientific content.

According Shulman (1986), science teaching orientation as a PCK component that specific attention offers a potential contribution to develop high quality science teacher. Magnusson, Krajcik and Borko (1999) postulated that science teaching orientation consists of five domains, comprising of: a) knowledge of a science-specific curriculum, b) knowledge of student understanding of science, c) knowledge of instructional strategies, d) knowledge of assessment of science learning, and e) orientation to teaching science.

Knowledge of science learning objectives is a sub-domain of a science-specific curriculum that teachers need to understand before teaching. Curriculum levels of a topic in a semester are constructed in a concept map. In this way, teachers comprehend the science learning outline and objectives (Friedrichsen, Driel, Van, & Abell, 2011). Knowledge of students' understanding of science and learning requirements refers to the knowledge of the students' understanding in studying particular scientific concepts (Lederman, 1999; Waters-Adams, 2006). Teachers' skills and abilities should meet the students' needs in learning science. They need to comprehend ways of preventing misconceptions during science learning (Faikhamta, 2013). Areas of students' difficulty cover a teacher's ability to understand their difficulties in learning science due to: 1) abstract concepts in areas such as protein synthesis, quantum mechanics, atoms and molecules, and cell respiration, 2) inappropriate method and learning model selection, 3) students having insufficient knowledge of effective ways of thinking in problem resolution, and 4) scientific misconceptions due to prior knowledge. These misconceptions are not easy to cope with because they are coherent and related to daily life (Lederman, Abd-El-Khalick, Bell & Schwartz, 2002). Teachers must understand the skills necessary to solve the problems using scientific methods, report and present practical results since scientific knowledge is obtained from reading, listening, observation, and practicum. In addition, they need to identify prior scientific knowledge and apply daily science experiences (Friedrichsen, Driel, Van, & Abell, 2011).

Specific strategies for science (for any topic) are ways to motivate students. Classroom management in problem-solving becomes centre on students applying problem-solving methods. Learning strategies consist of exploration, term induction, and concept application. The knowledge of subjects, pedagogy, and learning context affects a teacher's confidence (Faikhamta, 2013; Greene, Bolick, Jackson, Caprino, & Mcvea, 2015). The knowledge of scientific assessment dimensions includes conceptual understanding, interdisciplinary themes, nature of science, scientific investigation, and rational thinking. Portfolios or students' reports from practicum, discussion, and question-and-answer sessions about a scientific theme serve as a form of organising scientific concepts and principles (Adey, 2001; Anderson & Smith, 1987; Magnusson, Krajcik & Borko, 1999). Student portfolios such as journals, lab-work reports, anatomical diagrams, model media or multimedia documents can be used in assessments (Faikhamta, 2013; Jüttner, Boone, Park & Neuhaus, 2013; Koh, Woo & Lim, 2013).

Research Questions

This study focused on the following two research questions:

- What beliefs do pre-service primary education teachers have with regard to science teaching orientation?
- How are beliefs toward science teaching orientation influenced by demographic variables?

METHODS

Research Design

The aim of this research is to prepare the orientation and beliefs of pre-service teachers in Primary Teacher Education Programme to teach Science. The research was conducted using a mixed-methods study (in this research combines qualitative and quantitative methods) (Creswell, 2005; Merriam, 2002). The responses from the pre-service teachers who participated in the study were obtained using the survey method.

Participants

The participants were pre-service teachers in the Primary Teacher Education Programme at the Faculty of Teacher Training and Education of Universitas Sebelas Maret. The respondents consisted of 100 sixth semester students as the introductory-level participants and 120 eighth semester students as the advanced-level participants.

The participants aged between 20-24 years old at the time of this study. The eight semester students had completed courses in Natural Science Concepts. The educational background of the participants varied from science, non-science, and vocational education. Data of the participants are presented in Table 1.

Table 1
Participants' Profiles

Demography	Category	6th semester Student Introductory-level participants (n= 100)	8th semester students Advanced-level participants (n= 120)	Participants (N= 220)
High School Background	Science	30	53	83
	Non-science	24	43	67
	Vocational education	41	29	70
Sex	Male	45	30	75
	Female	75	70	145

Note: The ratio of female to male trainees on the teacher education programme was approximately 2:1

Instrumentation. The beliefs of pre-service teachers toward science teaching orientation was developed by Magnusson, Krajcik and Borko (1999). Questionnaires and interviews were employed to find data on their beliefs regarding science teaching orientation of the students in the Primary Teacher Education Programme. The 23-item questionnaire focused on determining the respondents' beliefs towards science teaching orientation (Kind, 2015). The questionnaire instrument used a 4-point Likert scale ranging from Strongly agree, Agree, Disagree, and Strongly disagree. The research subjects (the participants) were asked to complete the questionnaire and that there were no right or wrong answers (see the Appendix). The reliability of instrument with 23-item questionnaires to measure the beliefs towards science teaching orientation specific in Universitas Sebelas Maret education setting was measured by Cronbach's Alpha coefficients. Results of the reliability test indicated the items achieved an overall Cronbach's Alpha coefficient of 0.85, indicating that the scale used is highly reliable. In addition, in-depth interviews were conducted to find out the mastery of pre-service teachers in the subject matter and how to teach science toward the students. The interview transcripts served as the primary data source (Friedrichsen & Dana, 2005; Kind, 2015). A total of 40 pre-service teachers were interviewed. The 20-40 minute interviews were conducted in the Primary Teacher Education Programme (Table 2).

Table 2
The Pattern Pre-service Teacher responses for science teaching orientation based on the definition by Magnusson et al. (1999)

Advanced-level Participants	Introductory-level Participants
How do plants get nutrient?	What is the process of photosynthesis?
Then they show video animation showing how plants get nutrient. They explain photosynthesis by analogy. Discuss factors in photosynthesis; water, sugar, CO2, chlorophyll	Then they explain and discuss photosynthesis, that there no observation.
Introduce the idea that plants are different to animals. They explain the subject matter through thematic integrative example "The characteristic features of living things" is not separated in Biology, Physics, Chemistry	They explain that subject matter is separated in Biology, Physics, Chemistry
"I would explore the answers the children gave and use the information they should knowledge of science". They explain by way of hands-on and minds-on to avoid misconceptions. Teachers to understand the difficulties students face in science learning	They explain subject matter by studying literature rather than emphasising hands-on and minds-on
Represents science as inquiry, instruction requires students to investigate problems & assess knowledge. Use of questions with 'What', 'Why', 'How'.	They explain subject matter to find new concepts through individual rather than co-operative learning.
Method of assessment of science is only cognitive, affective and psychomotor. No understanding of assessment investigation portfolio, performance assessment, journal	Method of assessment is only by testing

Data Analysis

Data analysis was conducted using descriptive qualitative (the qualitative data are sourced from statements) and quantitative (quantitative data are in the form of questionnaires) data. The data were analysed quantitatively using SPSS for Windows. Statistical analyses such as descriptive statistics were used to analyse the data. Content analysis procedures were applied to pre-service teachers' responses. This technique was applied to determine the influence of the teachers' beliefs and science teaching orientation of prospective primary teachers.

The data were collected in 2015-2016 from the pre-service teachers who were taking the Science course, i.e. while they were in their sixth and eighth semesters. The questionnaire instrument was distributed to the sixth and eighth semester students with a completion time of about a week. The pattern of responses illustrates alignment belief that advanced-level participants and introductory-level participants.

The pre-service teachers in Primary Teacher Education Programme were classified into introductory-level participants comprising the sixth semester students, and the advanced-level participants consisting of the eighth semester students. They came from different high school concentrations such as science, non-science, and vocational education consist of male and female students. This study was done to compare the advanced-level participants and introductory-level participants. As shown in Table 3, there is no significant difference between the beliefs of introductory-level participants and advanced-level participants towards science teaching orientation, with t (0.75) p = 0.87.

Table 3
The Comparison between the Respondents' Beliefs in Science Teaching Orientation

		N	Mean (SD)	T	df	p-value	sig
Semester levels	The Sixth Semester/ Introductory	100	3.3		219		NS
	The Eighth Semester/ Advanced	120	3.4	0.75	219	0.87	NS
High School Concentrations	Science	83	3.4		219		NS
	Nonscience	67	2.7	0.67	219	0.5	NS
	Vocational Education	70	3.3		219		NS
Sex	Male	75	2.9	0.5	219	0.57	NS
	Female	145	3.3		219		NS

Note: comparison with statistic

RESULTS AND DISCUSSION

The research results indicate that the respondents consisting of eighth semester (advanced-level) and sixth semester (introductory-level) students understood the science teaching orientation to comprise of: a) knowledge of specific science curriculum, b) knowledge of student understanding of science, c) knowledge of instructional strategies, and d) knowledge of assessment of scientific literacy.

Table 4
Percentage of Beliefs towards Science Teaching Orientation

Aspect	Participants (Introductory)				Participants (Advanced)			
	Disagree		Agree		Disagree		Agree	
	1	2	3	4	1	2	3	4
a. Knowledge specific science curriculum	13	20	31	36	7	10	39	44
b. Knowledge of students' understanding of science	13	14	36	37	11	13	37	39
c. Knowledge of instructional strategies	10	11	48	31	29	14	17	40
d. Knowledge of assessment of science literacy	28	24	26	22	41	12	14	33

Note: comparison with percentage

Knowledge of specific science curriculum consists of: a) delivering science learning objectives relevant to daily life, b) outlining scientific concepts with concept maps and process skills as the unity of knowledge, c) teaching scientific concepts by first delivering problems and then conducting experiments, d) implementing science teaching orientation to grow in self-confidence when teaching, teaching science by implementing inquiry-based learning and problem-based learning (PBL), thematically and holistically delivering primary school science materials (Biology, Physics, Chemistry, and Earth & outer space). For Knowledge-specific Science curriculum, about 33% of the introductory level students disagreed and 67% agreed, whereas only 17% of the advanced-level students disagreed and some 83% agreed. For the aspect of knowledge of students' understanding of science, 23% of the advanced-level students disagreed and another 77% agreed, with 27% of the introductory-level students disagreeing and 73% in agreement. Meanwhile, for the aspect of knowledge of instructional strategies, 43% of the advanced-level students disagreed and some 57% agreed, while 21% of the introductory-level students disagreed and another 79% agreed. For the aspect of knowledge of assessment of science literacy, only 53% of the advanced-level students disagreed with some 47% in agreement, while 52% of the introductory level students disagreed and 48 % agreed (see Table 4). This means the introductory and advanced level students do not understand how the assessments in science learning work.

Both the introductory-level and advanced-level participants have nearly the same patterns of responses. The advanced-level participants, however, provided more varied answers since they had completed micro teaching course, as well as Field Experience and Practice, as demonstrated in Table 2. The pre-service teachers' atomised thinking in delivering Physics, Chemistry, and Biology materials resulted in non-integrated topics. The topic of Photosynthesis, for example, should focus not only on Biology, but also on Physics (since it involves the sun's energy transfer system) and Chemistry (since it involves chemical reactions). Therefore, the name of the topic should be changed to Energy Conversion in Plants. In this case, lecturers play an important role in guiding their students to apply scientific methods, specifically to formulate hypotheses and make data interpretation supported by expert views. In this study, gender has no effect on the pre-service teachers' belief in science teaching orientation. There is no relationship between knowledge of assessment and science teaching orientation (Aydin, Demirdogen, Akin, Uzuntiryaki-Kondakci, & Tarkin, 2015).

For example, material is delivering material about plants and animals, in which they applied a matching technique, while in fact, it would be better for them to implement a guided-inquiry learning or contextual teaching and learning (CTL). Some 60% of the respondents asked their students to work in groups and present their findings to the class. Concrete materials were used in the learning process by most of the respondents, but visual media such as pictures were still used by 20% of the respondents. Meanwhile, ICT (Information and Communications Technology) was used by the respondents to create PowerPoint presentations. They seldom displayed videos or animations for science learning; one example of an animation used in the classroom showed deglutition (swallowing) and peristalsis.

About half of the respondents excluded students' knowledge statements, describing only the content position. They may have assumed that there was no need to check on their students' understanding. However, this shows that the trainees focused on the transmission of the content knowledge rather than the students' perspectives. Thus, students' vignettes may be a limitation; responses are likely to reliably represent thinking about the situations. Evidence collected from experienced teachers (currently under analysis) indicates that shifting to considering students' thinking in lesson planning and delivery takes time. The advanced-level participants, however, provided more varied answers since they had completed the microteaching course, as well as Field Experience and Practice.

The introductory-level students and advanced-level students differ in their understanding of science as a body of knowledge. One of the reasons for the difference occurs is that the advanced-level students had completed Field Experience and Practice for 1.5 months and experienced microteaching, while the introductory-level students had just finished microteaching course.

Students in the Primary Teacher Education Programme came from different high school streams such as science, non-science, and vocational education. As shown in Table 3, there is no significant difference between their beliefs and science teaching orientation. However, during the in-depth interview session, the respondents who took science concentration in their high school could provide more detailed information and master the science teaching orientation better compared to those who took non-science and vocational education concentrations in their previous schools.

There is no significant difference in their beliefs toward science teaching orientation from the prospective of teacher's gender. Both the male and female prospective teachers have the same opportunity in learning and teaching science. This is in line with research results of Chabalengula, Mumba, and Chitiyo (2011) which proves that the attitudes towards biotechnology process were not influenced by gender. Prokop, Leskova, Kubiatko, and Diran (2007) stated that gender is important to consider regarding that sex is varied. The respondents in the present research were mostly female students (70%) and therefore gender was primarily considered. The research results in t (count) of 0.6 which is smaller than t (table) of 0.67, and this indicates no significant difference.

The results of the present research are relevant to those of studies of Kind (2015) and Jimoyiannis (2010), which proved that beliefs and science teaching orientation are linked. In this study, the introductory-level and advanced-level trainees differ in their understanding of science as a body of knowledge. One reason for this difference is that the advanced-level students had completed 1½ months of Field Experience and Practice, and had experienced microteaching, whereas the introductory-level students had just finished the microteaching course.

Students in the Primary Teacher Education Program came from different high school backgrounds such as science, non-science, and vocational education. However, during the in-depth interview sessions, the respondents who took science courses at high school were able to provide more detailed information and master the science teaching orientation better compared to others who took non-science and vocational education courses in their previous schools.

Meanwhile, the empirical data from in-depth interviews with and questionnaires completed by prospective primary teachers indicate that in science learning, syllabus construction was based on what was determined by the government and was carried out without innovation. Local potentials were not included in the syllabus, whereas in fact such local potentials as arts, food, and tourist resorts could be explored in thematic learning. Prospective teachers found difficulties in determining coherent indicators according to the determined basic competencies, as well as in relating science materials to both daily life and local potentials. Learning objectives were sometimes inappropriate, and at times were not achieved in core activities.

The belief has a significant effect on science teaching professions (Kolej, 2016) and the belief about Science is regarded as a component of subject matter knowledge and excluded from science teaching orientation (Kind, 2015).

With reference learning for students in Primary Teacher Education Programme, basic scientific concepts should be thematically and holistically delivered along with practicums. After the trainees have mastered their lesson contents, they should be taught how to transfer them to their primary school students. The lesson contents and the method of transferring them, therefore, are regarded as inseparable parts. This will benefit the trainees since they will immediately impart what they have learned to their primary school students. In this way, they will gain high self-confidence so that it is possible for them to have better attitude and perceptions when teaching Science.

CONCLUSION

With reference to the needs analysis of science learning for pre-service teachers in Primary Teacher Education Programme, the teaching and learning of Science more strongly influenced their responses than their beliefs about Science. For these pre-service teachers, science teaching orientation is personal, intuitive proposal that is separate from informed and partially-informed beliefs about science. STO is a factor for introductory to advanced participants in learning and teaching Science, but is inconclusive about "beliefs about science" as a component. The implication of this research is STO for pre-service teachers cannot be implemented and understand separately, and overall and sustainably. To be successful teachers in teaching, these teachers must master all components of the STO.

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APPENDIX

Questionnaire: Science Teaching Orientation

Item of science teaching orientation		P. Introductory				P. Advanced			
		Strongly disagree		Strongly Agree		Strongly disagree		Strongly Agree	
		1	2	3	4	1	2	3	4
A	Specific Science curriculum								
1	Communicate the objectives of science learning so that students understand the relevant science processes in everyday life								
2	Describe the concept of science with concept maps, process skills as a unity of knowledge								
3	Teach the concept of science by conveying problems then experiment								
4	Orientation teaching about science so that more confident in teaching.								
5	Teaching science with inquiry method & PBL								
6	Communicate thematic and holistic science materials in elementary school (Biology, Physics, Chemistry & earth & space)								
B	Knowledge of students' understanding of science								
7	Understanding the concept of science by reading, listening, and hands on minds on								
8	Construct the concept of science by doing observation								
9	Solve science problems with scientific method								
10	Misconceptions of science need to be avoided by hands on minds on								
11	Identify students' prior knowledge of science as a basic for beginning an orientation of teaching science								
12	Development of ideas from everyday science experiences								
13	Difficulty understanding the concept of science (Physics, Chemistry, Biology)								
14	Presenting the results of the experiment								
15	Engage discussion students to express their ideas when answering teacher questions								
16	Engage students to work group while solving problems								

APPENDIX *(continue)*

Item of science teaching orientation		P. Introductory				P. Advanced			
		Strongly disagree		Strongly Agree		Strongly disagree		Strongly Agree	
		1	2	3	4	1	2	3	4
C	Knowledge of instructional strategies								
17	Motivate students to explain the concept of science in their own mind								
18	Engage students working groups to solve science problems and interact with others								
19	The work procedures in experiment to understand in finding the concept of science								
20	Learning strategy with inquiry and Investigation develops the science process skills								
D	Knowledge of assessment of science literacy								
21	Assessment of science learning during in class and experiment								
22	Assessment of science learning with cognitive tests, attitudes and process skills								
23	Assessment of science with various strategies with presentation and portfolio of tasks								