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## **Successful Collaborative Problem Solving:**

### **A Case Study of Technology-Enhanced Assessment in the Context of Finnish Pre-Service Teacher Education**

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## **Abstract**

This chapter provides results from a case study utilising the ATC21S™ assessment portal in the context of pre-service teacher education in Finland. The results from the portal are combined with a questionnaire regarding teamwork and collaboration dispositions. Twenty-four pre-service teachers completed both these measures. The students of this study were following two divergent teacher education programs that had different profiles in terms of their study contents and methods of studying. The participants of both groups tended to be highly disposed to collaborate and work in teams, and their collaborative problem solving skills can be described as very good. The participants' measured social skills and self-assessed disposition to negotiate in the collaborative processes were strongly associated.

## **Introduction**

Finnish teachers are highly educated professionals. Whereas the traditional lecturing role of a teacher is still seen as essential, there are also many other roles, such as guidance and collaboration with other professionals, that are coming to be seen as more important parts of the teachers' profession (Krokfors et al., 2010). However, as noted in the ITL (Innovative Teaching and Learning) study (Norrena, 2013), even though 21<sup>st</sup> century skills are recognised and mentioned in the curricula of Finnish comprehensive schools, schools and especially individual

teachers vary greatly in their ability to facilitate the development of 21<sup>st</sup> century skills. Teachers themselves, particularly, consider teaching 21<sup>st</sup> century skills difficult (e.g. Niemi, 2012). It is generally up to individual teachers' discretion whether they include elements of innovative teaching and learning in their instruction. Therefore, teacher education units have a central role in contributing to this pedagogical evolution. Teacher education focused on developing 21<sup>st</sup> century skills has the potential, with a research-based curriculum and carefully designed learning practices, to provide new teachers entering schools with a better foundation to meet the many challenges of 21<sup>st</sup>-century learning environments (see Kong et al., 2013).

The Finnish national interest in fostering 21<sup>st</sup> century skills has highlighted a need for – and interest in the development of – tools and methods for teaching and assessing such skills. Assessment in Finland is often formative, based on constant evaluation of an individual student's development on different subjects. In addition, the forthcoming changes in the Finnish school curriculum in August 2016 towards phenomenon-based instruction with an emphasis on more interdisciplinary and generic skills and competencies have created a need for new forms of assessment. In this regard, technology-enhanced systems that enable formative assessment of complex performances involving collaboration are becoming more essential (Van Aalst, 2013; Binkley et al., 2012).

Finland's participation in the ATC21S project was a step towards better understanding of the assessment of more complex skills. While today's international and national standards primarily measure core subject performance (in math, science and reading), ATC21S designed new assessment prototypes to help education systems include the 21<sup>st</sup>-century skills that are essential to performing better in those core subjects. Finding technical solutions to meet schools' everyday pedagogical goals is an interesting and ongoing challenge. The work done in the ATC21S project continued as part of the "Preparing teacher students for 21<sup>st</sup> century learning practices", PREP21 project (Häkkinen, Järvelä, Mäkitalo-Siegl, Ahonen, Näykki, Valtonen, in press; PREP21, 2015; Pöysä-Tarhonen, Care, Awwal, Häkkinen, & Ahonen, 2016) The purpose of this study is firstly to acquire better understanding about the Finnish early stage pre-service teachers' dispositions' towards teamwork and collaboration. And secondly, by utilizing novel technology-enhanced assessment system of ATC21S™-portal, assess their existing level of collaborative problem

solving skills. By linking the students' own dispositions and self-assessment to objectively measured level of learning progressions on the areas of collaborative problem solving the aim is to investigate existing connections and disconnections between these measures. The research aim of this article is formulated as following research questions:

1. What is the current level collaborative problem solving skill among the two selected groups of pre-service teachers?
2. What kind of relation exists between teacher education students' collaboration and teamwork dispositions and assessed collaborative problem solving skills?

## **Method**

### **Participants and Context of Study**

The participants of the study were second year teacher education students (n=24, 21 female, 3 male) from one Finnish University. Teacher training program of this university follows phenomenon- and inquiry-based learning approaches. The phenomenon-based curriculum integrates, for example, the study of educational science and research methods into inquiry-based study projects. In addition to phenomenon-based approach, all the students study in home groups. Different home groups have different profiles in terms of their study contents and methods of studying. The students of this study were following two divergent teacher education programs (home groups). Common for both of these programs was that they apply phenomenon-based, collaborative modes of studying and are, hence, supposed to be experienced in engaging in productive collaborative activities, including collaborative problem-solving activities. Conducting study projects with schools was also present in both of these study programs. Active agency for own learning is emphasized in these study programs in terms of both students' own studying and in promoting pupils' learning at school.

Group A consisted of 12 students from a study program specializing in technology-enhanced learning (TEL). The goal of this group is to envision and experiment with the use of learning technologies with students in school settings. Hence, these students use also in their own studies multiple tools and technologies (e.g. personal mobile devices/tablets, social media, games) for individual access, manipulation and analysis of information as well as for communication,

sharing and joint knowledge construction with peers. As compared to group B, group A utilized the phenomenon-based approach more thoroughly and participated only minimally in traditional lectures. Another dimension that was more present in group A as compared to group B was collaborative teachership. The aim in this program is to model collaborative teaching for students by coaching and supervising them as a team of teacher educators. We call group A as “Technology” make the distinction between the two groups.

Group B consisted of 12 students following a program focusing on STEM-related themes, especially in science and mathematics. This group was leaning on inquiry-based curriculum, but they also participated in lectures more than group A. Although this group had emphasis on communities of teachers, they did not get a model of collaborative teachership in their own studies, but only one teacher at once was guiding their studies. We call group B as “Inquiry” to make distinction between the two groups of this study.

### **Measures**

To assess the pre-service teachers’ CPS skills from different perspectives, two measures were combined. First, a PREP21 self-report questionnaire was utilised. A set of questions based on the work of Wang and colleagues (2009), also applied as part of the PISA 2015 background questionnaire, was created to evaluate cooperation, negotiation and guidance. In this approach, these student dispositions are defined as general attitudes towards collaboration, collaborative problem solving and teamwork. Dispositions refer, thus, to students’ broader attitudes, beyond any particular collaborative learning situations or contexts. Accordingly, these dispositions are supposed to predict students’ performance in collaborative problem-solving activities (OECD, 2013). Also, obtaining a better understanding of teamwork as a set of skills and dispositions provides the grounds for deeper exploration of how students may acquire these skills and how instruction could be better designed to assist students in developing and applying these skills (Hughes & Jones, 2011) in professional settings.

The items referring to students’ dispositions towards collaboration, collaborative problem solving and teamwork were scored on a 7-point Likert-type scale, from 1 (not at all true of me) to 7 (very true of me). The subscales were formed based on responses for PREP21 survey from larger (N=263) sample of Finnish pre-service teachers. For the internal consistency of measured

subscales, Cronbach alpha was used. The reliabilities were measured as ( $\alpha=0.74$ ) for Cooperation- and ( $\alpha=0.75$ ) for Guidance and Negotiation-subscales. These can be indicated as adequate reliabilities of scale (Nunnally, 1978). First, negotiation is seen as a central element of teamwork, because an individual needs to negotiate and adjust his/her actions according to the surrounding group. Negotiation subscale comprises variables related with the ability to listen to others, flexibility and openness to others' thoughts and ideas. *Negotiation* was measured with six items: "I am a good listener"; "I enjoy seeing my classmates be successful"; "I take into account what others are interested in"; "I am flexible when working with a team"; "I enjoy considering different perspectives"; "I am open to all sorts of opinions". The subscale of *Guidance* includes the teacher education students' dispositions towards their skills to guide and mentor their other team members. The disposition of guidance was measured with six items: "I like to be in charge of groups or projects"; "I enjoy sharing ideas"; "I convince others to see things my way"; "I enjoy exchanging ideas"; "I like convincing peers"; "I enjoy bringing a team together". The subscale of *Cooperation* includes teacher education students' dispositions towards working together as a team. Cooperation was also measured with four items: "I prefer working as part of a team to working alone"; "I find that teams make better decisions than individuals"; "I find that teamwork raises my own efficiency"; "I enjoy cooperating with peers".

In addition to the survey of dispositions towards collaboration and teamwork, an assessment portal, ATC21S™, was used to assess their skills over the course of CPS activities. Each pair of students completed one bundle of assessment tasks comprising five tasks (Laughing Clowns, Plant growth, Balance, Olive oil and Game of 20 on group A and Small pyramids on group B) lasting 90 minutes. These tasks have been earlier described specifically by Care, Griffin, Scoular, Awwal & Zoanetti (2015) in the second volume. These were complex game-like tasks, mainly in the science and math domains, related both to curriculum content and to generic skills. The participating pairs proceeded well in the assessment, all of them could either enter or finish the last task (Game of 20 or Small pyramids). Moreover, in the ATC21S™ portal, students' completion of the assessment tasks yielded log file data. The data generated were captured in a process stream data file, and patterns in these data were automatically coded as indicators of the CPS elements (Adams, Vista, Scoular, Awwal, Griffin, & Care, 2015; Hesse, Care, Buder, Sassenberg, & Griffin, 2015). Furthermore, the tasks captured social and cognitive components

of students' CPS skills. Each of the skills could thus be scaled based on the actions taken by the students, which was collected as process data, together with the online chat discussions that took place while performing CPS tasks.

The scoring itself took into consideration students' actions as they moved through the tasks. The process data consisted of distinct keystrokes and mouse events that indicated exploration of the task environment, such as typing, clicking, dragging, cursor movements, hovering time and action sequences, all of which explicitly demonstrated students' thinking processes and skill levels. The log file data from the assessment tasks were processed by the ARCOTS system of the Assessment Research Centre of the University of Melbourne. All of the user actions and chat messages were recorded and time-stamped. The files generated for the automatic records of student-task interactions are referred to as session log files (Adams et al., 2015). Next, MySQL database architecture was used to record the interactions within the task environment. The scoring engine then automatically coded and scored data to produce reports for teacher and student use. Figure 1 describes an example of the reports on social and cognitive skills retrieved from the portal.

This particular student (fifpr0002a) below was estimated at a level five for her cognitive skills and a level six for her social skills.

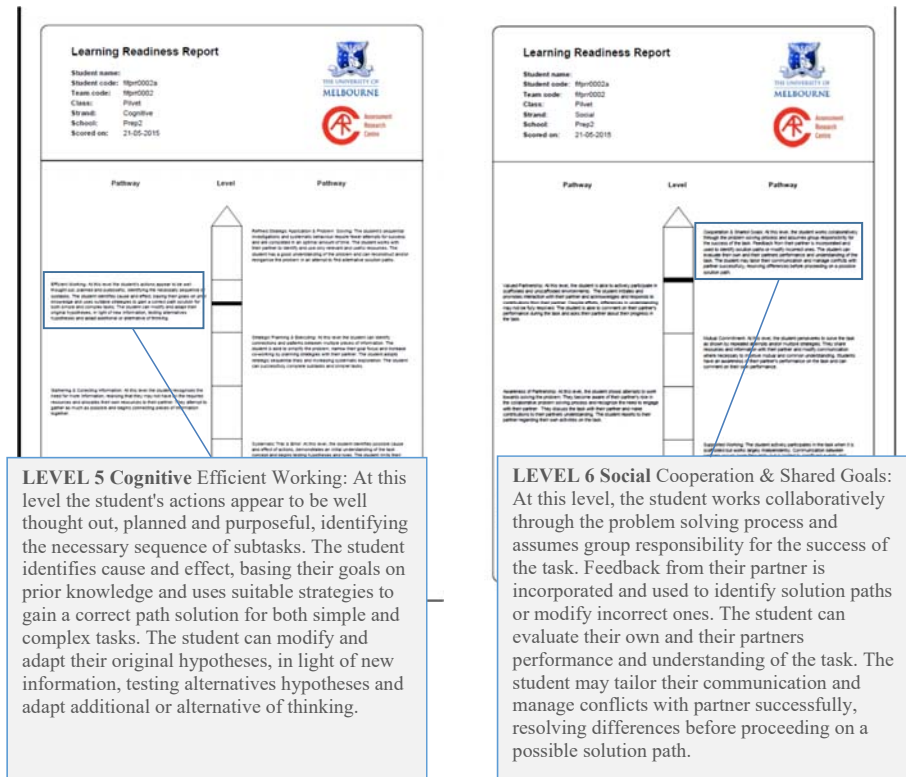


Figure 1 Learning readiness reports from ATC21STM portal: cognitive and social skills

## Data analysis

Scores on respondents' skill level estimates were firstly drawn from the ATC21TM assessment portal by utilizing the Rasch modelling on ConQuestTM program. All analysis was performed using ConQuestTM (Wu 1998), a Multi-Aspect Test Software, using a Partial Credit model with Guass-Hermite Quadrature estimation with 15 nodes. These skill level estimates were then utilized to make the skill level reports. According to the procedures on Rasch modelling the average of the task scores has been set on zero and the difficulty of the item is presented as an estimate describing the level the students was based on their result on the bundle of task they had completed. Each student received a Weighted Likelihood Estimate score (WLE), which could



vary from -4 to 4 on both social and cognitive dimensions. The report displays are based on the Weighted Likelihood Estimate scores (WLE) distributed on different levels of learning progression, presented in table 1.

Table 1 Range of WLE scores in the ATC21S portal corresponding to the Learning readiness levels

Level of Learning progression	WLE Range Social 2D1	WLE Range Cognitive 2D2
1	below -1.3	below -3.5
2	-1.3 between -0.7	-3.5 between -0.8
3	-0.7 between -0.5	-0.8 between 0.5
4	-0.5 between 0.3	0.5 between 1.7
5	0.3 between 1.5	1.7 between 2.1
6	above 1.5	above 2.1

The participants were analysed as whole and divided as two separate groups based on their study group. SPSS v 22 was then used to investigate confidence intervals (using T-tests), descriptive statistics and correlation on the whole data and between the two groups. The statistical significance of mean differences was tested using the variance analysis of One Way ANOVA. Due to the small sample size, the correlations were counted with non-parametric Spearman's rho. We used the general criteria to interpret the correlation coefficients: 0.10 – 0.29 for weak, 0.3 – 0.49 for moderate, 0.5 – 0.69 for strong, and above 0.7 for very strong associations between variables (c.f., Cohen 1988). The statistical significance values are displayed by the p-value or by the \*-symbol. The representation of the symbols is as follows: \*\*p<.01, \*p<.05.

## Results

The descriptive statistics for the scores received from the ATC21S™ portal and PREP21 questionnaire dispositions for all participants are presented in Table 1. The ATC21S™ portal WLE scores are presented separately for social and cognitive skills. Pre-service teacher students' social skills were reported with a mean of 1.92 (SD=0.65), which falls in the highest level 6 of learning progression. Their cognitive skills were reported with a mean of 1.62 (SD=1.02), which

represents level 4 of learning progression. The level of social skills was rather consistently at the very top level, but cognitive skill levels varied and were overall on lower level when compared to social skills. The dispositions from the PREP21 questionnaire were indicated being on a rather high level. The mean of *Guidance* was 5.32 (SD=0.65), the mean of *Cooperation* was 5.25 (SD=1.24) and the mean of *Negotiation* was the highest, at 6.08 (SD=0.75) on a scale of 1 to 7. Due to the small sample size, and the fact that the sample responses were not normally distributed, correlations were counted with non-parametric Spearman's rho. There was one strong correlation between the disposition variables and measured WLE scores. *Negotiation* correlated significantly and positively ( $r=0.57^{**}$ ) with the ATC21S™ portal social skills WLE score. ATC21S portal cognitive skills WLE score did not have statistically significant correlations on any measured variables. The disposition variables also correlated significantly with each other. Negotiation correlated strongly ( $r=0.57^{**}$ ) with cooperation and moderately ( $r=0.41^{*}$ ) with guidance. Also cooperation correlated moderately ( $r=0.41^{*}$ ) with guidance.

Table 1 Descriptive Statistics, 95 % Confidence Interval of Difference, Spearman's rho

Measured skills		Descriptive					One sample T-test					
	Items	scale	min-max	<i>M</i>	<i>SD</i>	<i>CI</i>		1	2	3	4	5
1 WLE Social	1	-4-4	0.71-3.85	1.92	0.65	[1.64, 2.19]						
2 WLE Cognitive	1	-4-4	-.39-3.38	1.62	1.02	[1.19, 2.05]	.57**					
3 GUIDANCE	6	1-7	4.0-6.67	5.32	0.65	[5.05, 5.60]	.19	.17				
4 COOPERATION	6	1-7	2.25-7.0	5.25	1.24	[4.72, 5.78]	.15	-.13	.48*			
5 NEGOTIATION	4	1-7	3.33-6.83	6.08	0.75	[5.77, 6.40]	.57**	.00	.41*	.57**		

Note.  $N = 24$ . \*\*  $p < .01$ , \*  $p < .05$

Due to small number of respondents, it was also possible to examine each student's scores and dispositions individually based on their study groups. Table 2 presents these individual measures separately. The WLE scores were indicated as levels of learning readiness based on Rasch modeling of the item difficulties. There were no significant differences of the mean scores between the two groups of pre-service teachers. Still, group A "Technology"s scores were more

consistent, with lower standard deviations on both social and cognitive WLEs when compared to group B “Inquiry”. Group A students also indicated their dispositions generally slightly higher than group B students. But only, on negotiation the difference was statistically significant ( $p < .05$ ), when group A mean was 6.40 and group B mean was 5.76. When Social skills WLE were associated with negotiation dispositions, it can be interpreted that students from both groups utilized their negotiation capacity well in the social processes of collaborative problem solving. When examining the dispositions on individual level, it is possible to recognize that four students from group B were indicated their negotiation dispositions below 6 and two of them below 5. When compared to group A, only one student’s dispositions were below 6. When examining the results of individual student ID 5a, it can be interpreted that her social skills WLE was also measured on the lowest level (1.29) on group A. When examining the results of individual students from group B it can also be interpreted that student ID 21a had responded her dispositions being rather low levels on cooperation (3.00) and negotiation (3.33), which are actually the lowest ratings of all. Also her skills were measured the lowest with ATC21S portal. In this particular case the portal measurement and student’s own dispositions met exceptionally well. Still, this particular students’ pair ID 21b, had very high ratings on the portal, when her both social and cognitive skills were measured on the very top level. Despite her very high measured skills, her dispositions did not indicate as high expectations towards her skills on teamwork and collaboration, when compared to other high scoring students. Only clear difference, when compared to her pair 21a, was that her dispositions on negotiation were clearly higher (4.67). This indicates that negotiation dispositions had clear association with this student’s measured social skills. This finding gets support from the positive association with negotiation disposition and Social WLE.

Table 2 Individual portal scores and dispositions

Group A Technology						Group B Inquiry					
ID	Soc WLE (level)	Cog WLE (level)	COOP	GUID	NEGO	ID	Soc WLE (level)	Cog WLE (level)	COOP	GUID	NEGO
Mean (SD)	1.97 (.42)	1.54 (.63)	5.71 (1.02)	5.49 (.59)	6.40* (.31)		1.86 (.84)	1.70 (1.32)	4.79 (1.30)	5.17 (.69)	5.76* (.97)
2a	1.77(6)	1.93(5)	4.00	5.00	6.00	19a	1.22(5)	0.11(3)	5.50	4.83	6.17
2b	2.19(6)	1.51(4)	6.00	6.00	6.67	19b	1.79(6)	1.36(4)	4.50	5.50	6.33
3a	2.58(6)	1.28(4)	7.00	5.50	6.83	20a	1.52(6)	3.38(6)	5.00	5.33	5.33
3b	2.14(6)	1.66(4)	5.50	5.83	6.50	20b	1.86(6)	3.31(6)	5.25	5.00	5.83
4a	2.25(6)	1.93(5)	6.25	4.33	6.33	21a	0.71(5)	-0.39(3)	2.25	4.50	3.33
4b	2.14(6)	1.80(5)	5.75	6.17	6.17	21b	2.07(6)	3.19(6)	3.00	5.00	4.67
5a	1.29(5)	0.81(4)	5.50	5.00	5.83	22a	3.85(6)	3.38(6)	6.25	6.67	6.33
5b	1.86(6)	0.85(4)	7.00	5.00	6.67	22b	1.41(5)	1.02(4)	6.00	5.50	6.17
6a	1.94(6)	1.54(4)	6.00	6.33	6.67	23a	1.67(6)	1.45(4)	4.00	4.67	6.17
6b	1.62(6)	2.50(6)	6.00	5.83	6.33	23b	1.31(5)	0.95(4)	6.75	5.83	6.33
7a	1.35(5)	0.38(3)	6.00	5.67	6.17	24a	3.05(6)	1.81(5)	4.50	4.00	6.33
7b	2.54(6)	2.32(6)	3.50	5.17	6.67	24b	1.86(6)	0.91(4)	4.50	5.17	6.17

\*the mean difference between groups A and B is statistically significant  $p < .05$

## Discussion and conclusions

Recent developments in technology-enhanced assessments have made it possible to evaluate complex performance such as collaborative problem solving better than before. In this study, we used the ATC21S™-portal to assess teacher education students' collaborative problem-solving skills (CPS). We also utilised a PREP21 self-report instrument to measure more general collaboration and teamwork dispositions. According to our results, the current level of collaborative problem-solving skills among these students was generally high; measured levels of social skills were especially high, as compared to cognitive skills. Social skills were also connected positively with collaboration and teamwork dispositions –in particular negotiation. Meanwhile, the cognitive skills scores did not correlate with teamwork and collaboration dispositions. This indicates that the social aspect of collaborative problem solving is probably the key for success in these kinds of shared tasks.

The respondents were representing two different study groups with slightly different implementation of their study programs. Group A “Technology” focused particularly on

technology-enhanced learning, and group B “Inquiry” follows the STEM-related program. Common for both of these programs was that they apply collaborative modes of studying. It can be assumed that these students have been trained to be more familiar with productive forms of collaboration and collaborative problem solving than an average group of students. As compared to group B, group A has a slightly stronger focus on phenomenon-based curriculum with hardly any lectures in their studies. Furthermore, they also got a model of collaborative teaching as they were coached and supervised by a team of teacher educators.

Group A “Technology” had very constant high results on social skills as compared to group B “Inquiry”. Both groups had higher social skills than cognitive skills, but there were no significant mean differences between the groups. When recognized that negotiation had statistically significant and positive correlation with social skills WLE scores measured by the ATC21S portal, this finding gives support to the assumption that there is factual connection between these two independent measures.

Given the adaptations that a society based on knowledge and competency demands from school pedagogy, it has to be remembered that teacher education also needs to be adjusted to meet the challenges. Pre-service teachers have a central role in developing 21<sup>st</sup> century learning practices and promoting skills such as collaborative problem solving in future schools. In Finland, autonomy is typical for the teaching profession, which also means that teachers often work too independently and alone. As the skills to solve complex, cross-curricula problems in teams become more important in our society, teachers should acquire these skills also by themselves. In general, the adoption of new pedagogical innovations has been unsuccessful primarily because too little attention has been paid to teacher's own learning processes (Lieberman & Pointer Mace, 2008). Thus, it is argued here that the task of teacher education is to guide these processes.

Pre-service teachers are themselves the result of traditional school culture, which strongly influences their assumptions regarding good teaching models (i.e., favouring models featuring a traditional teacher-led approach) (Mäkitalo-Siegl, Kohnle, & Fischer, 2011; Schratzenstaller, 2010; Webb & Mastergeorge, 2003). We believe that pre-service teacher education could be a powerful means of sparking long-term change in the field. To create change in schooling, pre-service teachers first need to learn how to adapt to the new learning culture. One of the specific aims of the PREP21 project is to outline the analysis and pedagogical designs regarding students’

collaborative problem-solving skills and the related pedagogical practices in pre-service teacher training programs. Based on this experimental study it can be justified that skills needed in successful collaborative problem solving measured by ATC21S™-portal benefit from collaborative practices of instructional methods in teacher training. Utilising this web-based portal to measure collaborative problem solving in the pre-service teacher education context was the first pilot in advancing the assessment of students' complex skills. It can be concluded that these tasks are welcomed and well suited to pre-service teacher training.

Next, we will apply the ATC21S™ portal in the context of teacher education on a wider scale, in which the assessment session is followed by debriefing of students' scores. With larger number of respondents, we will also be able to examine the interesting associations between teamwork dispositions, self-assessment and the ATC21S™ portal. In addition, by monitoring their performance during the tasks by applying online measures of their performance (e.g. by capturing screen activity) and combining it with subjective data (e.g. cued retrospective interviews) (see Pöysä-Tarhonen et al., 2016) we might also be able to better understand the individual differences monitored over the course of this study.

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